#114

RT-200 Calibration Analyzer™

Operation/Service Manual

THE TIMETER GROUP

Timeter Instrument Corp.
Mistogen Equipment Co.
Timeter International, Inc.

2501 Oregon Pike Lancaster, Pennsylvania 17601 U.S.A.
Telephone: 717/569-2695 Toll-Free: 800/233-0258
Telex: 466 816 TIM LNSCI FAX: 717/569-7834

13

RT-200 CALIBRATION ANALYZER

(Consisting of RT201M Control Module, RT202 Pressure Module, RT203 Flow Module)

TIMETER INSTRUMENT CORPORATION
2501 Oregon Pike
Lancaster, PA 17601 U.S.A.

Contract No. DLA-120-88-C-8511

RT-200 OPERATION/SERVICE MANUAL

May 1988

TABLE OF CONTENTS

USER INSTRUCTIONS

1. INTRODUCTION. 1-1
   - A. General 1-1
   - B. Equipment Supplied. 1-2
   - C. Equipment Required But Not Supplied 1-3
   - D. Specifications. 1-4

2. PRECAUTIONS 2-1

3. INSTALLATION INSTRUCTIONS 3-1
   - A. Initial Inspection. 3-1
   - B. Voltage Configuration/Fuse Replacement. 3-1
   - C. Functional Test 3-3
   - D. Claims, Repackaging, and Factory Service. 3-3

4. FEATURES AND CONTROLS 4-1
   - A. The RT-200 System 4-1
   - B. Power Up Procedure. 4-2
   - C. Keypad. 4-2
   - D. Display 4-4
   - E. Function Codes. 4-6
   - F. Entering and Zeroing Functions. 4-7
   - G. Selecting the Proper RT-200 Inlet Port. 4-8

5. OPERATION
   - A. Pressure Module Measurements
     1. Measuring Constant Pressure 5-1
     2. Measuring Pressure In Volume Cycled Machines.5-2
     3. Measuring Pressure Differentials. 5-2
   - B. Flow Module Measurements
     1. Measuring Flow Rates. 5-3
     2. Measuring Tidal Volume And Minute Volume. . .5-3
     3. Measuring Accumulative Tidal Volumes For Multiple Breaths. 5-3
     4. Measuring Breath Rate, Inspiratory Time And I:E Ratio 5-4
     5. Measuring Inspiratory Time, Expiratory Time And I:E Ratio On Ventilators with Hold Modes.5-5
     6. Measuring Oxygen/Nitrogen Mixtures. 5-5
     7. Measuring Oxygen/Nitrous Oxide Mixtures . . .5-5
     8. Measuring Air/Nitrogen Mixtures 5-7

TABLE OF CONTENTS (Continued)

6. OPERATIONAL CONSIDERATIONS
   - A. Availability of Special Functions 6-1
   - B. Gas Correction (ATP, BTPS, STP) 6-2
   - C. End-of-Breath and Start-of-Breath Delays. 6-3

7. USER TROUBLESHOOTING AND HELP MESSAGES. 7-1

MAINTENANCE INSTRUCTIONS

8. THEORY OF OPERATION 8-1
   - A. Control Module. 8-2
   - B. Pressure Module 8-3
   - C. Flow Module 8-4
   - D. Module Interconnect Bus 8-6

9. ROUTINE MAINTENANCE 9-1
10. SCHEMATICS AND TROUBLESHOOTING CHARTS 10-1
11. ASSEMBLY PICTORIALS WITH PART NUMBERS 11-1
   - A. RT-200 System Parts List. 11-2
   - B. Control Module Parts List 11-4
   - C. Pressure Module Parts List. 11-6
   - D. Flow Module Parts Lists 11-8

12. EQUIPMENT NEEDED. 12-1
13. STORAGE INSTRUCTIONS. 13-1
14. GENERAL INFORMATION 14-1
   - A. Changing EPROMs 14-1

APPENDIX

A. Recalibration Statement A-1

INDEX OF FIGURES

Figure#	Figure Title	Page#
Fig.1.1	Accessory Pouch Contents.	.1-2
Fig.2.1	External Filter	.2-1
Fig.3.1	Fuse Case	.3-1
Fig.3.2	Fuse Block Removal.	.3-1
Fig.3.3	Fuse Arrangements	.3-2
Fig.3.4	Voltage Selector Card Orientation . .	.3-2
Fig.4.1	RT-200 Front View	.4-1
Fig.4.2	Control Module Front View	.4-2
Fig.4.3	Display	.4-4
Fig.5.1	Differential Test Set-up.	.5-2
Fig.5.2	N20 Test Set-ups.	.5-6
Fig.6.1	Waveform With Trigger Points.	.6-3
Fig.6.2	Correction Equation	.6-5
Fig.6.3	Measuring Flow Outlet Pressure. . . .	.6-5
Fig.8.1	RT-200 System Block Diagram	.8-1
Fig.10.1	Control Module Schematic.	10-2
Fig.11.1	RT-200 System Assembly Pictorial. . .	11-1
Fig.11.2	Control Module Assembly Pictorial . .	11-3
Fig.11.3	Pressure Module Assembly Pictorial. .	11-5
Fig.11.4	Flow Module Assembly Pictorial. . . .	11-7

INDEX OF TABLES

Table #	Table Title	Page#
Table 1.1	Accuracy Specifications Charts. . . .	.1-4
Table 4.1	Keypad Functions.	.4-2
Table 4.2	Possible Display Messages	.4-4
Table 6.1	Special Functions Applicability . . .	.6-1
Table 7.1	User Troubleshooting Chart.	.7-1
Table 7.2	Help Messages	.7-2
Table 8.1	Module Interconnect Bus	.8-7
Table 8.2	Function and LED Select Line Voltage Level vs Function Selected.	.8-8
Table 9.1	Routine Maintenance Schedule.	.9-1
Table 10.1	Control Module Troubleshooting Chart.	10-3
Table 10.2	Pressure Module Troubleshooting Chart	10-5
Table 10.3	Flow Module Troubleshooting Chart . .	10-6

1. INTRODUCTION

A. GENERAL

The RT-200 is a portable pneumatic calibrator designed to eliminate the cumbersome tangle of equipment often used to test hospital/medical equipment. The RT-200 uses microprocessor technology to accurately measure gas pressure, pressure differentials, flow rate, tidal volume, minute volume, breath rate, inspiratory/expiratory ratio and other functions. It is also programmed to allow compensations for various gas conditions and mixtures. It includes a peak-detect mode, a digital display, self diagnostics, and more.

The RT-200 is designed with a light-weight, portable, modular case so it can easily be carried anywhere precise measurements are needed. The RT-200 performs calibrations, service and preventive maintenance on most respiratory care and related equipment. It offers convenience, flexibility, and on many parameters, accuracy of 1% or better.

This manual provides the information needed to use the RT-200 most effectively. Please take the time to read it thoroughly. If there are any questions on RT-200 use, please call Timeter at (800) 233-0258. Call Collect in PA (717) 569-2695.

CERTIFICATION

Timeter Instrument Corporation certifies that this instrument has been thoroughly tested and inspected to meet its published specifications before being shipped from the factory. The results of this testing and the standard used for certification are shown on the Function Specification Sheets sent with each RT-200.

COPYRIGHT RELEASE - Timeter authorizes the United States Government to duplicate any or all of the information in this manual.

B. EQUIPMENT SUPPLIED (Reference Fig.11.1)

1. RT-200 Calibration Analyzer System
2. Transit Case
3. Dust Cover
4. Package of Function Specifications Sheets
5. Operation/Service Manual.
6. Full Accessory Pouch (002-021) containing the following items:

	Part Number
a. One 22mm ID x 22mm ID tubing adaptor	930-003
b. Two 22mm OD x 22mm ID x 3/16 ID tubing tee	930-004
c. One 22mm OD x 22mm OD w/15mm tubing adaptor	930-002
d. One 22mm ID x 3/16" ID tubing adaptor	930-001
e. O-DISS Thumb Nut	Z51
f. One 1/4" x 1/4" x 3/16" Tubing Tee	002-007
g. One 3/16" ID tubing tee	864-001
h. External Filter*	11534
i. One 1 Amp 3AG fuse	503-001
j. Two 0.5 Amp 5 x 20 mm Fast Fuses	8004
k. Two 24" lengths 3/16" ID vinyl tubing	11845.0006
l. Pouch	690-001

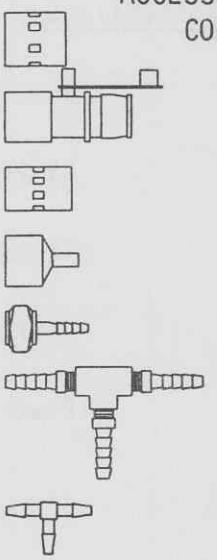


FIG.1.1
ACCESSORY POUCH CONTENTS

* This item is not included in accessory pouch #002-021. It is only put in the accessory pouch when the RT-200 is packaged for storage or shipping. Whenever the RT-200 is in use, this filter must be installed on the high flow inlet port.

C. EQUIPMENT REQUIRED BUT NOT SUPPLIED

1. Test Lung - Needed when testing ventilators or equipment that requires back pressure.
2. Vacuum Regulator - If N2O is tested, this is needed to scavenge the N2O.
3. Miscellaneous Tubing - (22mm) Any tubing, other than 3/16" ID vinyl, needed for custom test set-ups.

D. SPECIFICATIONS

RT-200 Dimensions: 31 W x 26 H x 29 D (centimeters)
12 W x 10-1/2 H x 11-1/2 D (inches)
RT-200 Mass: 7 kg (15-1/2 lbs.)

Transit Case Dimensions: 44.5 W x 42.5 H x 41.3 H (centimeters)
17-1/2 W x 16-3/4 H x 16-1/4 D (inches)
Transit Case Mass: 9 kg (19-3/4 lbs)

Power Requirements: As shipped from factory: 120 VAC, 50/60 Hz,70 VA
Field configurable to:

100 VAC	50/60 Hz
220 VAC	50/60 Hz
230/240 VAC	50/60 Hz

Operating Conditions:
Temperature*: 10 to 40° C (50 to 104° F)
Humidity: 20-80% RH

Storage Conditions:
Temperature: -30 to 60° C (-22 to 140° F)
Humidity: 10-90% RH

Power Cord: 3 m (10.6 ft.) with hospital grade plug

Service Life: 7 years

Warranty: 1 year

* Accuracy not guaranteed over entire temperature range. See "ACCURACY SPECIFICATIONS" below for temperature conditions.

TABLE 1.1 ACCURACY SPECIFICATIONS CHARTS

RT202 PRESSURE MODULE

Test Function	Range	Resolution	Accuracy	Comments
Low Range Pressure/ Vacuum	0 to +20.00 cm H_2O −20.00 to 0 cm H_2O	.01 cm H_2O	±1% of reading or ±2 digits at 70°F ±2% of reading or ±2 digits at 15°–35°C	Sensor: Solid state differential pressure transducer.
	0 to +250.0 cm H_2O −250.0 to 0 cm H_2O	.1 cm H_2O	±0.5% of reading or ±2 digits at 70°F ±1.5% of reading or ±2 digits at 15°–35°C	Overpressure: 4 psi (300 cm H_2O, 225 mm Hg)
	0 to +185.0 mm Hg	.1 mm Hg	±0.5% of reading or ±2 digits at 70°F ±1.5% of reading or ±2 digits at 15°–35°C	Maximum common mode pressure: 15 psi
High Range Pressure/ Vacuum	0 to +20.00 psi −15.00 to 0 psi	.01 psi	±0.5% of reading or ±2 digits at 70°F ±1.5% of reading or ±2 digits at 15°–35°C	Sensor: Solid state differential pressure transducer.
	−15.0 to 100.00 psi	.1 psi	±0.5% of reading or ±1 digit at 70°F ±1.5% of reading or ±1 digit at 15°–35°C	Maximum common mode pressure: 100 psi
	0 to +5170 mm Hg −760 to 0 mm Hg	1 mm Hg	±0.5% of reading or ±1 digit at 70°F ±1.5% of reading or ±1 digit at 15°–35°C	

RT-203 FLOW MODULE

Test Function	Gas (mixture)	Range	Resolution	Accuracy at 70°F	Accuracy at 59–95°F
Low Flow Range	O_2, N_2, Air (O_2/N_2), (O_2/N_2O), N_2O, CO_2	0–5 lpm 0–5 lpm	.01 lpm .01 lpm	±2% reading or ±2 digits ±3% reading or ±2 digits	±4% reading or ±2 digits ±5% reading or ±2 digits
High Flow Range	O_2, N_2, Air, (O_2/N_2) O_2/N_2O, CO_2, N_2O	5–180 lpm 20 lpm	.1 lpm .1 lpm	±1% reading or ±1 digit ±2% reading or ±2 digits	±2% reading or ±1 digit ±4% reading or ±2 digits
Volume	O_2, N_2, Air, (O_2/N_2)	3 liters	.01 lit.	±1% reading or ±1 digit	±2% reading or ±1 digit (Flow Rate 120 lpm Maximum)
Rate bpm	—	2 to 150	.1 bpm	—	±.5% reading or ±1 digit
Inspiratory Time	—	.1 to 5 sec	.001 sec	—	±.5% reading or ±3 digits
Expiratory Time	—	.1 to 99 sec	.01 sec	—	±.5% reading or ±1 digit
I:E Ratio	—	1:.10 to 1:9.9	.01, .1	—	±.5% reading or ±1 digit (Autoranges)

List of Fuses:

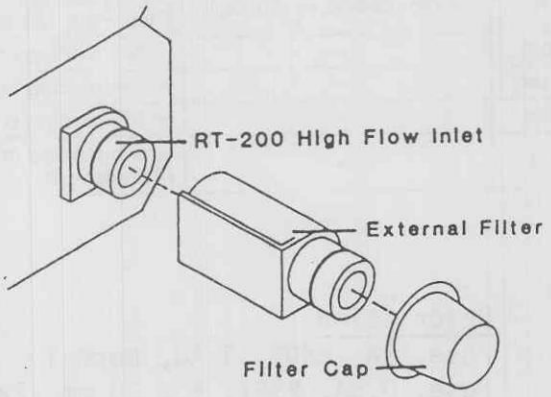
Qty	Part#	Description
1	503-001	Fuse, 1A, 250V, 3 AG, Normal
2	8004	Fuse, 0.5A, 250V, 5 x 20 mm, Fast

List of Semi-conductors: N/A - No field serviceable devices.

2. PRECAUTIONS

- TEST ONLY CLEAN, DRY GASES WITH THE RT-200. Corrections are available to simulate other gas conditions. See chapter 6, section B.
- DANGER, possible explosion hazard if used in the presence of flammable anesthetics.
- ELECTRICAL SHOCK HAZARD: Do not remove the cover. Refer servicing to qualified service personnel only.
- DO NOT substitute parts without permission from the Timeter Repair Shop. Such substitutions can cause premature product failure and may void warranty.
- Grounding reliability can be achieved only when equipment is connected to a receptacle marked "HOSPITAL GRADE."
- DO NOT use power cord adaptor plugs.
- Always follow the "POWER UP PROCEDURE" in chapter 4 to prepare the RT-200 for use. If this procedure is not used, measurements may not be accurate.
- An external filter is included in the RT-200 Accessory Pouch to prevent dirt from affecting the accuracy of the high flow transducer. Before making hook-ups to the high flow range port, attach this filter. When the high flow range port is not being used the external filter can be left in place. Cover the filter and the high range outlet on the back of the unit with the caps provided to prevent dirt from entering. See Fig.2.1.

FIG.2.1 EXTERNAL FILTER



- Modules are not interchangeable from one RT-200 system to another. Make sure the serial numbers of each module in the system are the same.

3. INSTALLATION INSTRUCTIONS

A. INITIAL INSPECTION

Unpack the RT-200 Calibration Analyzer as soon as it is delivered. Save the box and packing materials for future shipping or storage. Make sure all the items listed in "EQUIPMENT SUPPLIED" (page 1-2) are included. Check the exterior of the unit for shipping damage. If there is exterior damage, DO NOT attempt to use the unit. Refer to section D below.

If there is no apparent damage, verify that the items listed in chapter 1, section B are included in the shipment. Notify Timeter if any of these items are missing.

B. VOLTAGE CONFIGURATION/FUSE REPLACEMENT

The RT-200 is field configurable to four different voltages as listed in "SPECIFICATIONS". It is shipped from the factory in the 120 volt configuration. To change the voltage configuration, follow the instructions below. The process involves three steps 1) fuse changing; 2) changing the voltage selector card and; 3) power plug switching.

WARNING:
UNPLUG THE POWER CORD FROM THE REAR OF THE RT-200 BEFORE PROCEEDING!

1. To Change Fuses:
   a. Pry the cover (Fig.3.1, Item 1) off the fuse case using a small screwdriver at #2 in Fig.3.1.

FIG.3.1 FUSE CASE

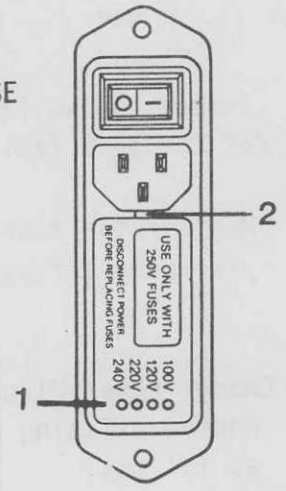
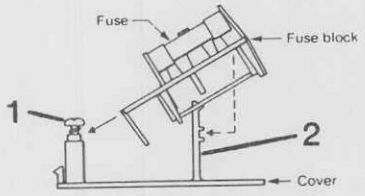


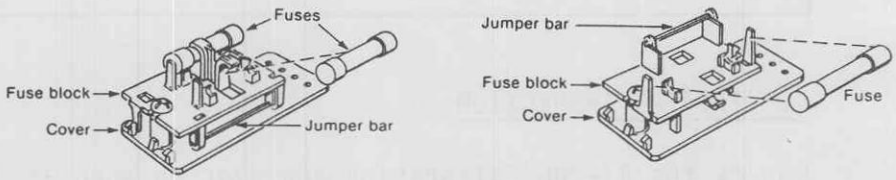
FIG.3.2 FUSE BLOCK REMOVAL



   b. Loosen the fuse block Phillips screw (Fig.3.2, Item 1) two turns.
   c. Remove the fuse block (Fig.3.2) by sliding it up, then away from the Phillips screw and lifting it from the pedestal (Item 2).

d. Change the fuses noting Fig.3.3. 220 and 230/240 volt applications require two fuses (1/2 amp 5 x 20mm). 100 and 120 volt applications require only one fuse (1A, 3 AG).

FIG.3.3 FUSE ARRANGEMENTS



e. Reinstall the fuse block with the desired fuses exposed as in Fig.3.3 and retighten the Phillips screw.

2. To Change Voltage Selector Card

a. With the cover (Fig.3.1, Item 1) off, the voltage selector card can be seen in the bottom of the fuse case. The voltage selector is a small circuit board. Pull the voltage selector card out of the case.

b. Notice that along each edge of the card the available voltages are printed. Turn the card so that the edge with the desired voltage is down. Position the white plastic indicator pin so that the it is at the top edge of the card. See the different orientations in Fig.3.4.

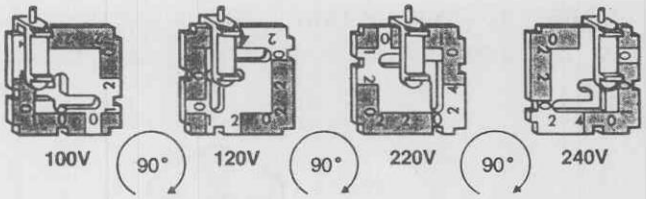


FIG.3.4 VOLTAGE SELECTOR CARD ORIENTATION

c. Insert the voltage selector card back into the fuse case with the printed side of the card facing up and and the indicator pin out.

d. Replace the fuse case cover, making sure selector card indicator pins protrudes through the proper voltage hole in the cover.

3. To Change Power Plug.

a. Remove existing plug and install proper type. The internal cable colors are as follows:

Brown = Hot
Blue = Neutral
Green/Yellow = Ground

C. FUNCTIONAL TEST

After the initial inspection, make sure the RT-200 works properly:

1. Attach the RT-200 power cord to a Hospital Grade Outlet.
2. Turn the RT-200 on. The power switch is on the rear of the control module.
3. After a few seconds this reading will appear on the display:

E _ _

If the RT-200 fails test or "HELP E" appears on the display, see Section C. below.

D. CLAIMS, REPACKAGING AND FACTORY SERVICE

If the RT-200 does not pass initial inspection or fails the functional test, notify the Timeter Service Department at the telephone number listed below within 7 days and corrective action will be taken. Unless damage occured after delivery, Timeter will repair or replace your RT-200 without waiting for the claim against the carrier.

If the RT-200 appears to malfunction, refer to Chapter 7.

When returning the RT-200 system to the factory, use the following procedure:

1. Call the factory to obtain return authorization.
2. Identify the unit to be returned by a purchase order containing the name and address of the owner, the serial number and model number, and the specifics of the service required.
3. Carefully pack the RT-200 in the transit case (Fig.11.1).
   a. Remove the external filter from the high flow range inlet and store it in the accessory pouch. Cap the high flow range inlet and outlet with the dust covers that are attached by chains to the side of the RT-200.
   b. Unplug the power cord connector from the back of the RT-200 (it is not necessary to remove the cable clamp). Coil the power cord and secure it with a cable tie or twist tie.
   c. Place the RT-200 in the polyethylene bag with the power cord behind the RT-200. Pull the bag up and around the RT-200 and tuck any extra bag material under the carrying handle.
   d. Put the operation/service manuals in the bottom of the transit case and place the RT-200 on top of them.
   e. Store the accessory pouch behind the RT-200 and the dust cover in the transit case lid. Close the transit case lid and secure the latches.
4. Ship the RT-200 fully insured. All shipments to Timeter must be prepaid. Shipping damage in transit to Timeter is the customer's responsibility.

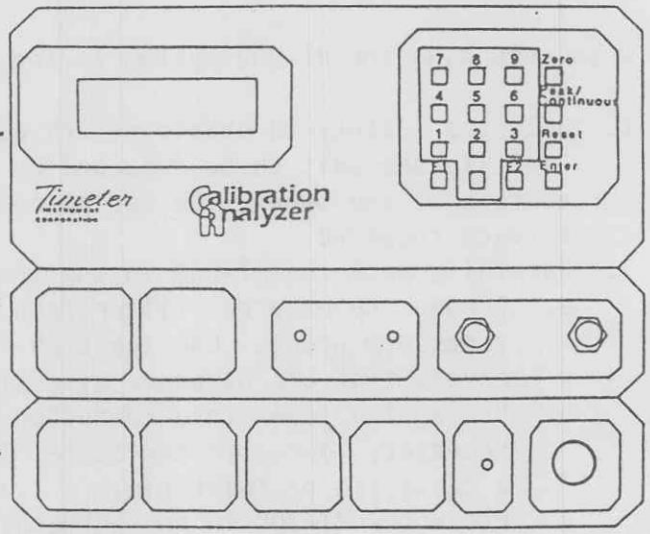
Individual modules may be returned for service or recalibration. Contact Timeter for details. Refer other questions to Timeter at (800) 233-0258. IN Pennsylvania call COLLECT (717)-569-2695.

4. CONTROLS AND FEATURES

A. THE RT-200 SYSTEM

Figure 4.1 shows the "standard" RT-200. It consists of three modules: a Control Module and two "function" modules, flow and pressure, which maybe ordered separately or as a system.

FIG.4.1
RT-200 FRONT VIEW



1. The Control Module (Model RT-201M) is the "brain" of the RT-200, and controls all of its operations. The keypad and display are located on the Control Module.

2. The Pressure Module (Model RT-202) contains the transducers and circuitry for measuring various ranges of pressure and vacuum.

3. The Flow Module (Model RT-203) contains the transducers and circuitry for measuring gas flow rate, volumes, breath rate, inspiratory and expiratory times and I:E ratio.

The system can be expanded to include other modules as they become available. See chapter 8 for more detail on how the system and its components work.

B. POWER UP PROCEDURE

1. Make sure the external filter (from accessory pouch) has been installed on the high flow range inlet port.
2. Plug the RT-200 power cord into a standard hospital grade outlet.
3. Turn on the power. The power switch is on the rear of the Control Module. After a few seconds, the indication "E _ _" will appear on the display.
4. Remove the plugs from the high range flow inlet on the front of the flow module and the high flow outlet on the back.
5. Allow the RT-200 to warm up for about five minutes before taking measurements. If readings are taken immediately after power up, they may not meet normal accuracy limits.

C. KEYPAD

The keypad is on the right side of the Control Module front panel. See Fig 4.2. The keypad is used to select functions. Below is a listing of the keys and function they play in the RT-200 system.

FIG.4.2 CONTROL MODULE FRONT VIEW

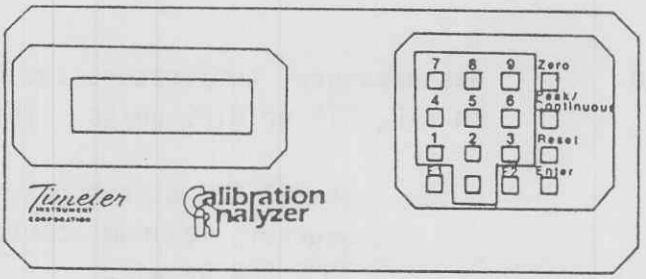


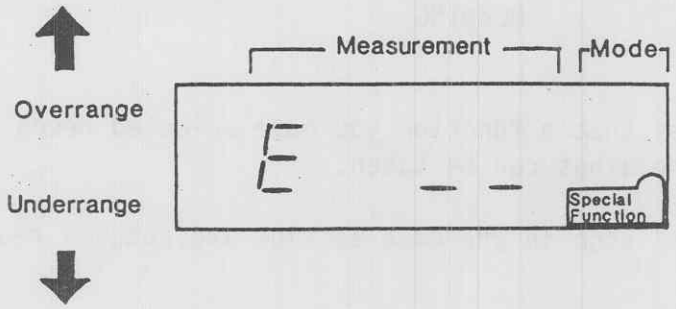
TABLE 4.1 KEYPAD FUNCTIONS

Key(s)	Function
0 - 9	Used to enter Function Codes
Enter	After typing in a Function Code, pressing this key activates the function.
Zero	"Zeros" the display to compensate for electronic drift. See section F for more detail.
Peak/ Continuous	Toggles between Peak and Continuous (normal) modes. Peak mode displays the peak values of a test. In Peak mode, a "P" appears in the Mode section of the display. Some functions are not affected (see Fig.6.1).
Reset	Reset to power-up condition. The "E _ _" prompt appears on the display. Zero offset values and special functions selected remain. RT-200 is left ready for commands from the keypad.

Table 4.1 Keypad Functions (continued)

Key(s)	Function
	The functions below are known as the RT-200's "Special Functions"!
F1	Flow and volume measurements of oxygen (O2) and nitrogen (N2) mixtures or oxygen and nitrous oxide (N2O) mixtures. A special mode can also be entered using "F1" for measuring inspiratory and expiratory time and I/E ratio on ventilators with a inspiratory hold modes (see page 5.3).
F2	Measure accumulated tidal volume for multiple breaths, 1-10 breaths.
0 0	Gas pressure, temperature and humidity correction. Shows flow and volume in ATP, STP or BTPS units. The RT-200 defaults to ATP. NOTE: The RT-200 allows gas temperature to vary between 59-95°F, however, maximum accuracy is achieved using 70°F dry oxygen or 70°F 20% RH air.
0 1	Alters start and end-of-breath delays and triggering level. Applies to all measurements triggered by the start/stop of flow or pressure. Is useful in cases where pnuematic noise, waveform ringing, etc. cause false triggering. **CAUTION**: DO NOT USE this function to pass malfunctioning equipment! Investigate and solve any abnormal pnuematic noise (leaky ventilator valves, poor test set-up, etc.) before using the "0 1" function.
0 9	Resets Special Functions to power up condition without losing zero values.

FIG.4.3 DISPLAY



D. DISPLAY

The RT-200 display consists of three segments. See Fig.4.3.

1. OVERRANGE AND UNDERRANGE INDICATORS: Located to left of display. The overrange lamp lights when the display reading exceeds the accuracy range of the function selected. If the reading rises far enough past the accuracy range, the display will blank. The overrange lamp will still be lit. This is called the "blanking point." It prevents the RT-200 from displaying grossly inaccurate readings. The "blanking point" varies with each function. It is listed on the function specification sheets sent with each RT-200.

   The underrange lamp lights when the display reading goes below -10 or a reverse flow exists. Negative readings, down to -10, are displayed with a minus sign in the mode section of the display. If the underrange lamp lights, make sure tubing connections are tight and to the proper inlet port.

2. MEASUREMENT: This four-digit section normally contains the measurement. Self-diagnostic messages may also appear in this section. See the next section for a list of the possible display messages.

3. MODE: See the next section of this chapter for the list of symbols that may appear in this segment.

TABLE 4.2 POSSIBLE DISPLAY MESSAGES

This section lists possible readings, codes and messages which may appear on the display. "123" is used to represent any numeric reading, X is used to represent a number from 1 to 9 or a letter.

DISPLAY	MEANING
E _ _	This is the keypad entry prompt. The CONTROLLER is waiting for you to type in a function code or some other command.

Table 4.2 Possible Display Messages (continued)

DISPLAY	MEANING
oooo o	Indicates that a function you have selected needs to be "zeroed" before readings can be taken.
0.01 -	A "minus" sign in the mode section indicates a reading below zero.
1.23 P	Indicates that the RT-200 is in peak-detect mode. The reading will not change until another peak is encountered.
1-2.3	I:E ratio reading of 1 to 2.3.
° 100.3	Overrange lamp lit indicates a reading above the upper limit of the function.
°	Overrange lamp lit with blank display indicates that the reading is beyond the upper limit of the function.
°	Underrange lamp lit with blank display indicates that the reading is more than 10 below zero.
HELP X	This "HELP message ("HELP" followed by a number or letter) shows that an error condition has been detected. See page 5.1.
. 1.23	Underrange lamp with a reading shows that flow or peak pressure is negative. The display shows the last valid, positive reading.
100.3 .	When the LED in the special function display is lit, one of the special functions mentioned on page 4-3 is in effect.
E _ _ P	Shows that Peak/Continuous key was pressed before the full FUNCTION CODE was entered. The RT-200 will be in peak-detect mode as soon as the FUNCTION CODE is entered.
C 100	Shows that oxygen concentration is 100%. Applicable to oxygen/nitrogen and oxygen/nitrous oxide mixtures.
A 010	Shows that 10 breaths will be accumulated. See "Pressure Module Measurements", chapter 5.
0.00 H	Shows that inspiratory hold mode is in effect. See "Flow Module Measurements", Chapter 5.

Table 4.2 Possible Display Messages (continued)

DISPLAY	MEANING
F 100	Shows end-of-breath delay time. See section C, Chapter 6.
r 050	Shows start-of-breath delay time. See section C, Chapter 6.
L LO	Shows the breath detection level is set at low. See section C, Chapter 6.
L HI	Shows the breath detection level is set at high. See section C, Chapter 6.

E. FUNCTION CODES

The flow and pressure modules have several ranges and units of measure identified by "FUNCTION LABELS". These labels appear in windows on the module front panels. A two-digit "FUNCTION CODE" is printed next to each label. This code is entered to activate the function (see section F below). On standard RT-200s, Function Code "11" refers to the 20 cm H2O pressure measurement function*. When the 20 cm H2O function is needed, enter "11".

* Other units of measure can be custom made if specified at the time of order. On "custom" RT-200's, Function Code "11" may not be 20 cm H2O.

F. ENTERING AND ZEROING FUNCTIONS

1. Scanning the Function Labels on the module to be used, select the proper Function Code. (see "FUNCTION CODES" earlier in this chapter).

2. Press the number keys that correspond to the Function Code. (i.e. To enter FUNCTION CODE "12" press "1", then "2"). If a mistake is made, press Reset and repeat this step. As each digit is pressed, it will appear on the display.

3. Press the "Enter" key. The lamp next to the FUNCTION LABEL will light, showing which function is selected. To change functions, simply type in the new Function Code and press "Enter".

4. If "oooo o" appears on the display, "zero" the function:
   a. Disconnect all tubing attached to the module inlet fittings (pressure or flow). **CAUTION**: The function can only be properly "zeroed" if there is no pressure or flow applied to the inlet fittings.
   b. Press the zero key. All the segments of the display will light briefly to test the display, and then a reading of zero will appear. The RT-200 is now "zeroed".

ZEROING

NOTES:
- The zero values are stored as long as the RT-200 remains powered up. If the unit is turned off or power is interrupted, they are lost.
- When the RT-200 is first turned on, the function to be used will need to be "zeroed".
- It is a good practice to re-zero the RT-200 just before critical measurements.
- If special functions or triggering options are selected, they will be briefly displayed after the Zero key is pressed.

Try these alternate methods of entering functions!

- Enter the FUNCTION CODE, then press the Zero key. The RT-200 selects the function and immediately "zeroes it". This method enters and "zeros" with one keystroke.
- Enter the FUNCTION CODE, then press the Peak/Continuous key. This enters the function and immediately switches it to peak-detect mode (if allowable). The function must still be zeroed.
- Enter the first digit of the FUNCTION CODE, then press the Zero key. Enter the second digit of the FUNCTION CODE and press the Peak/Continuous key. The RT-200 selects the function, immediately saves a "zero value", and switches to peak-detect mode (if allowable).

G. SELECTING THE PROPER RT-200 INLET PORT

1. Determine whether the function selected is a low range or a high range function.

   To do this, look at the front panel of the module being used.
   a. Low Range Functions - The Function Labels, LED's and Function Codes are bordered by a black line and labeled "Low Range".
   b. High Range Functions - The Function Labels, LED's and Function Codes are bordered by an ivory line and labeled "High Range".

2. Determine which ports are used for low range functions and which are used for high range functions. To do this look at the inlet ports on the module being used.

   a. Low Range Inlet Ports - These are bordered by a black line and are labeled, depending on which module is being used, "Low Flow Range" or "Low Pressure Range".
   b. High Range Inlet Ports - These are bordered by an ivory line and labeled, depending on which module is being used, "High Flow Range" or "High Pressure Range".

3. Use the fittings illustrated on page 3-1 to connect your equipment set-up to the RT-200.

   a. For Flow Module functions: Simply make the attachments.
   b. For Pressure Module functions: If a positive pressure is being tested, make the tubing connection at the "P+" port. If a negative pressure (vacuum) is being tested, make the tubing connection at the "P-" port.

5. OPERATION

Make sure the RT-200 is powered and warmed up. See page 4-2 before proceeding.

A. PRESSURE MODULE MEASUREMENTS (Function codes 11-14 and 21-24)

TARE WARNING

DO NOT use the Zero key as a "Tare" function. DO NOT "zero" the RT-200 while any amount of pressure is being applied. If you "zero" the RT-200 while pressure is applied, you will get inaccurate readings because of the transducer linearization technique used. This technique assumes that the "zero value" measured when the Zero key is pressed corresponds to NO pressure. When this assumption is not true, incorrect linearization and inaccurate readings will result.

1. Measuring Constant Pressure

Since the pressure transducers in the RT-200 are deadheaded, pressure must be bled off between tests before the display can change. This is done by simply breaking the tubing connection and bleeding to atmosphere pressure.

a. Enter and zero the Function Code (Chapter 4, section F).
b. Connect the tubing from the equipment being tested to the proper inlet port (see Chapter 4, section G).
c. Apply pressure using a clean, dry gas.
d. Read the display. The correct reading appears in the display.
e. Check the "zero" periodically.

2. Measuring Peak Pressure in Volume Cycled Machines

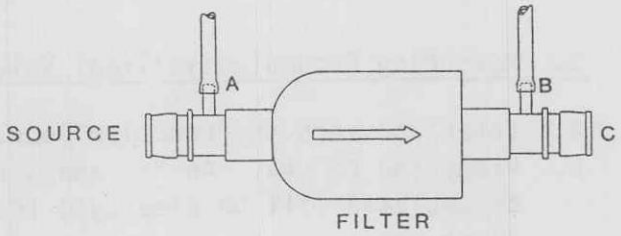
Because the transducers in the pressure module are deadheaded, a test lung must be used to collect the volumes delivered from breathing machines.

a. Enter and zero the Function Code (Chapter 4, section F).
b. Press the "Peak/Continuous" key. Make sure that "P" appears in the mode segment of the display.
c. Press "0", "1" then press "Enter" three times. The display should read "L LO". Press any of the numerical keys so that the display changes to "L HI", then press "Enter". (You have just raised the RT-200's breath detection level. This is necessary because the test lung will not empty enough to trigger the RT-200 off between breaths if the trigger level is set too low. For further discussion of the trigger levels, see Chapter 6, section C.)
d. Attach tubing from the equipment being tested to a test lung.
e. Tee off of this tubing to the pressure inlet port on the RT-200.
f. Cycle the equipment being tested.
g. Read the display. The correct reading appears in the display.
h. Check the "zero" periodically.

FIG.5.1 DIFFERENTIAL TEST SET-UP

3. Measuring Pressure Differentials

The RT-200 has the ability, and includes the connectors, to make several pressure differential measurements. This can be helpful in measuring the degree of occlusion in filters or leakage in a system. To check the degree of occlusion, use the test set-up shown in Fig.5.1.



a. Enter and zero the function code needed to measure flow rate through the filter (31-33, 35-37).
b. Tee in 3/16 tubing between the source and the filter (Item A). Run this tubing to the Low Pressure Range P+ port on the RT-200.
c. Tee in 3/16" tubing after the filter (B) and run it to the Low Pressure Range P- port on the RT-200.
d. Connect the filter outlet (C) to the high flow inlet port.
e. Apply flow and adjust the flow rate to the manufacturer's reference.
f. Enter the function code needed to measure the expected pressure differential (11-13, 21-23).

B. FLOW MODULE MEASUREMENTS (Function Codes 31-33, 35-37, 41-43, 45-48)

1. Measuring Flow Rates (Function Codes 31-33, 35-37)

a. Enter and zero the Function Code.
b. Connect tubing from the equipment being tested to the proper RT-200 inlet port.

WARNING: DO NOT measure low range flow rates while flow is passing into the high flow range inlet. False low readings will result.

c. Apply flow, using clean, dry gas only.
d. Read the display. The correct flow readings will now appear on the display.
e. Check the zero periodically.

2. Measuring Tidal Volumes And Minute Volume (Function Codes 41-42 and 43)

a. Enter and zero the Function Code.
b. Connect tubing from the equipment being tested to the RT-200's high flow range inlet.
c. Apply flow and cycle the equipment being tested.
d. Read the display. The tidal volume appears on the display at the end of each breath. For minute volumes, the reading shows the volume delivered in one minute based on alternate readings of tidal volume and breath rate.
e. Rezero the unit periodically.

3. Measuring Accumulative Tidal Volumes for Multiple Breaths (Function Codes 41-42)

a. Enter and zero the Function Code.
b. Press the F2 key. An "A" and a number representing the number of breaths to be accumulated will be displayed (defaults to "one breath, normal tidal volume" on power up).
c. Enter the number of breaths to be accumulated, 1-10. (Three digits must be entered. i.e. 4 breaths must be entered as 004. If not entered properly, the last allowable value or the default value will be displayed.)
d. Connect tubing from the equipment being tested to the RT-200's high range flow inlet.
e. Apply flow and cycle the equipment being tested.
f. The display will show the accumulated tidal volume and the number of breaths as the equipment cycles. After the selected number of breaths has been reached, the test halts. To restart the test, push "Enter".

IMPORTANT: Whenever tidal volume air or oxygen functions are entered, the RT-200 will return to the accumulate mode. To return to normal tidal volume, repeat steps b and c above, entering only <u>one</u> breath.

4. Measuring Breath Rate, Inspiratory Time, Expiratory Time and I:E Ratio

(Function Codes 45-48)

If the breath cycle being tested includes an inspiratory hold, see section 5, below.

a. Enter and zero the Function Code.
b. Connect tubing from the equipment being tested to the RT-200's high flow range inlet port.
c. Apply flow and cycle the equipment being tested.
d. Read the display. The correct reading will appear on the display.
e. Rezero the unit periodically.

NOTE: Peak-detect mode is not available on these functions. If Peak/Continuous is pushed nothing will happen.

5. Measuring Inspiratory Time, Expiratory Time and I:E Ratio on Ventilators with Hold Modes (Function Codes 46-48)

a. Enter and zero the Function Code.
b. Press the F1 key. An "H" will appear on the display, showing that the inspiratory hold mode is in effect.
c. Connect tubing from the equipment being tested to the RT-200's high range flow inlet.
d. Connect a test lung to the outlet on the back of the RT-200. (The test lung must be used to provide reverse flow through the RT-200 during the expiratory cycle.)
e. Apply flow and cycle the ventilator.
f. The measurement will appear on the display. The inspiratory hold time is included in the inspiratory time.
g. Rezero the unit periodically.
h. Press F1 again to turn the hold mode off.

6. Measuring Oxygen/Nitrogen Mixtures (or pure Oxygen or Nitrogen)

(Function Codes 31,35,41)

a. Enter and zero the Function Code.
b. Press the F1 key. The O2 percentage will appear on the display. (The O2 percentage defaults to 100% on O2/N2 mixtures.)
c. Change the O2 percentage to the value of the gas mixture being tested: Enter the percentage (0-100) using the number keys and press "Enter". (Enter three digits. Ex: enter 021 for 21%.) If the value is not entered properly, the last allowable value or the default value will be displayed. If so, repeat this step.
d. Connect tubing from the equipment being tested to the proper RT-200 inlet port (see chapter 4, section G.)
e. Apply flow using clean dry gas and check the display for the reading.
f. Check the "zero" periodically.

NOTE: When an O2 percentage is entered into a Function Code, it is automatically entered into the other Function Codes for that same mixture. i.e. If you enter 21% (021) into the low flow O2/N2, the high flow O2/N2 and O2/N2 volume functions will also be entered at 21%. To remind the user of this, the O2 concentration is momementarily displayed (with other special functions entered) when a Function Code of the same mixture is entered. To check what special functions are in effect at any time during operation, press "Enter".

7. Measuring Oxygen/Nitrous Oxide Mixtures (or pure Oxygen or Nitrous Oxide)
(Function Codes 33,37)

READ THE NITROUS OXIDE WARNING BELOW BEFORE PROCEEDING!

a. Enter and zero the function code.
b. Press the F1 key. The O2 percentage will appear in the display. (The O2 percentage defaults to 0% on O2/N20 mixtures.)
c. Change the O2 percentage to the value of the gas mixture being tested: Enter the percentage (0-100) using the number keys and press "Enter". (Enter three digits. Ex: enter 021 for 21%). If the value is not entered properly, the last allowable value or the default value will be displayed. If so, repeat this step. Read "NOTE" in section 6 above.
d. Connect tubing from the equipment being tested to the proper RT-200 inlet port (see chapter 4, section G).
e. Apply flow using clean, dry gas and check the display for the reading.
f. Check the zero periodically.

NITROUS OXIDE WARNING:
Long term exposure to moderate levels of nitrous oxide is suspected to adversely affect decision-making ability. NIOSH, the research arm of the Occupational Safety and Health Administration (OSHA), recommends that maximum exposure level should not

exceed an eight-hour, time-weighted average of 25 parts per million. Although OSHA does not publish a requirement for nitrous oxide exposure, Timeter recommends adherence to the NIOSH limit given above. To help comply with this limit the RT-200 includes a nitrous oxide scavenging bracket. Follow the instructions below to use use the RT-200 scavenging bracket and your hospital vacuum source to vent nitrous oxide out of your work area.

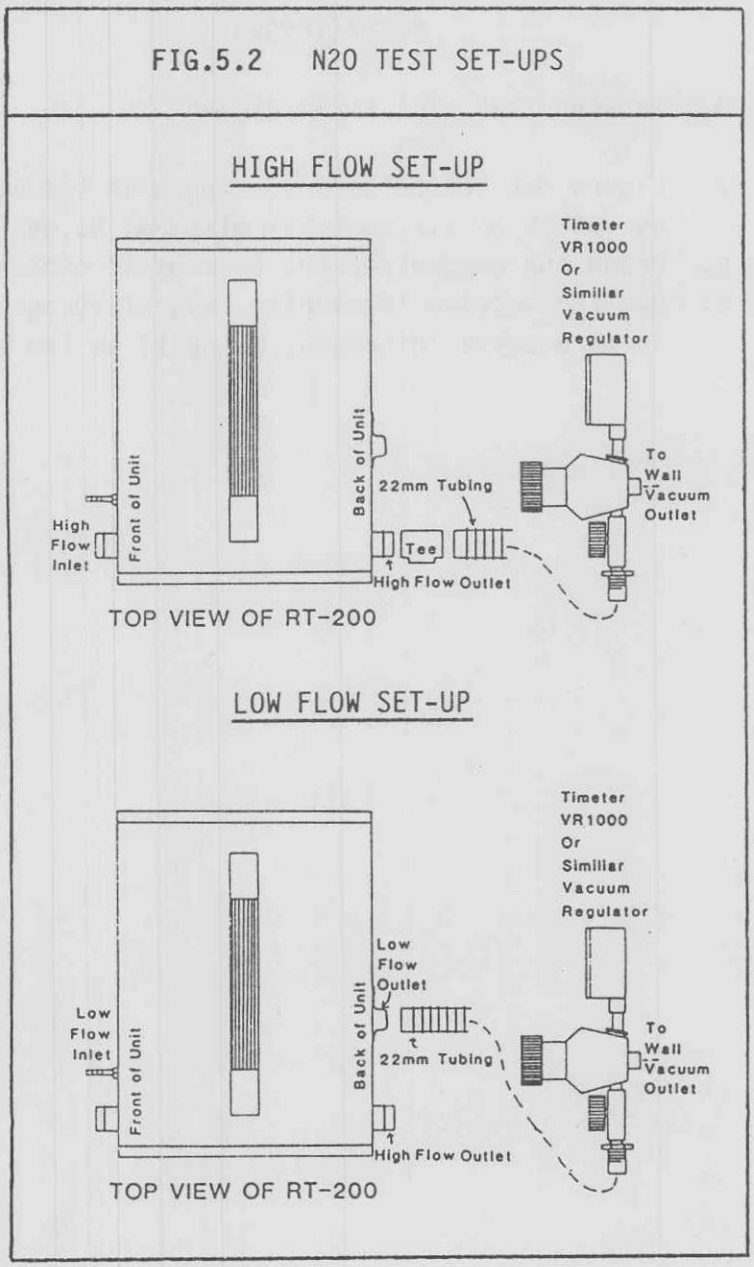
a. High Flow Measurements (0-20 lpm N20)

1. Enter and zero the 180 lpm Air function.
2. Attach 22mm tubing from a regulated vacuum source to the high flow OUTLET on the back of the RT-200.
3. Remove all connections from the high flow INLET.
4. Adjust the vacuum source so the RT-200 display shows a flowrate 10-15 lpm HIGHER than what you expect to measure.
5. Remove the 22mm tubing from the high flow outlet and attach the 22mm tee to the tubing. (Fig.5.2).
6. Enter and zero the high flow N20 function.
7. Reconnect tubing and tee to high flow outlet. DO NOT connect anything to the open port on the tee.
6. Connect the N20 source to the inlet and proceed with measurements.

b. Low Flow Measurements 0-5 lpm N20

1. Follow steps 1-3 above.
2. Adjust the vacuum source so the RT-200 display shows a flowrate of 20 lpm $\pm$ 2.
3. Disconnect the tubing from the high flow outlet and reattach it to the scavenging bracket over the low flow OUTLET. (Fig.5.2).
4. Enter the 5 lpm N20 function.
5. Attach the N20 source to the low flow INLET and proceed with measurements.

FIG.5.2 N20 TEST SET-UPS



8. Measuring Air/Nitrogen Mixtures

As you know from previous sections, the RT-200 can make flow and volume measurements on mixtures of oxygen and nitrogen. So, using a mathematical calculation, you can measure air and nitrogen mixtures in a similiar fashion.

For example:

Given a mixture of 60% air
40% nitrogen

And knowing that air is 21% oxygen:

a. Figure out the percent of oxygen in the mixture. This is done by multiplying .21 by .60 (% of air in total mixture) to get .126.
b. Round the oxygen percent to closest percent, 13%.
c. Use the section "Measuring Oxygen/Nitrogen Mixtures" to measure the mixture as if it were oxygen/nitrogen, using 13 as the oxygen concentration.

6. OPERATIONAL CONSIDERATIONS

A. Availability of Special Functions

Special functions apply to the test functions indicated in Figure 6.1.

TABLE 6.1 SPECIAL FUNCTIONS APPLICABILITY

◯ = AVAILABLE Ⓟ = AVAILABLE IN PEAK ONLY

SPECIAL FUNCTION	KEY(S)	PRESSURE	FLOW (LOW & HIGH)				TIDAL VOLUME		MINUTE VOLUME		T I M E			
		ALL	AIR	O2	N2O	SPEC	AIR	O2	AIR	O2	BPM	TINSP	TEXP	I/E RATIO
O2/N2 MIXTURES	F1			◯				◯		◯				
O2/N2O MIXTURES	F1				◯									
HOLD MODE	F1											◯	◯	◯
ACCUMULATIVE VOLUME	F2						◯	◯						
ATP, STP, BTPS	0 + 0		◯	◯	◯	◯	◯	◯	◯	◯				
START & END-OF-BREATH DELAY TRIGGER LEVEL	0 + 1	Ⓟ	Ⓟ	Ⓟ	Ⓟ	Ⓟ	◯	◯	◯	◯	◯	◯	◯	◯

B. GAS CORRECTION

The RT-200 allows the choice of three different gas pressure, temperature and humidity corrections.

ATP: (ambient temperature and pressure) This is the RT-200's default value. It assumes the test gas temperature is 70° F. If the temperature varies from 70°F, the RT-200 allows entry of the actual test gas temperature.

STP: (standard temperature and pressure) This corrects measurements to 70° F and 760mm Hg. In this mode, the user enters barometric pressure. The RT-200 compensates for gas temperature, but gas temperature must be between 59-95°F.

BTPS: (body temperature, 98.6°F and ambient pressure, saturated with water vapor) This allows testing to be done using **DRY** gas from an oxygen cylinder (on oxygen ranges) or an existing humidity air source (on air ranges) and corrects the gas flow/volume to its equivalent BTPS reading. This is useful because BTPS gas MUST NEVER be allowed to flow through the RT-200 or it will be damaged. The gas temperature must be between 59-95°F.

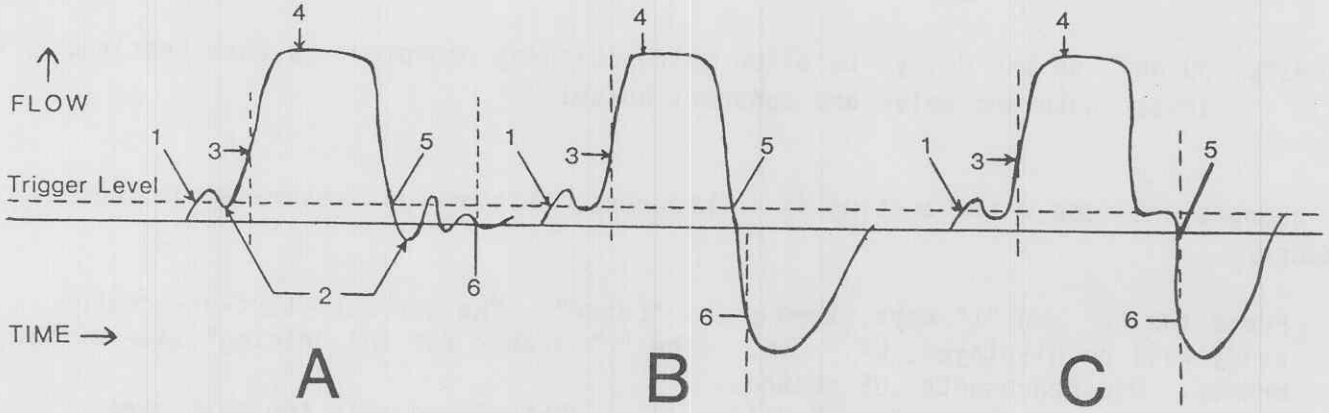
If gas corrections are entered while testing is in progress, testing will resume after the function is entered. To change the gas corrections factor:

1. Press the "0" key twice. Then press "Enter".
2. a. To accept the displayed choice of conditions, press the Enter key.
   b. To choose another condition, press the "1" key until your choice appears in the window, then press "Enter".
3. If the condition selected requires entry of a gas temperature (ATP) or barometric pressure (STP), a "t" or "P" prompt will appear with the last pressure or temperature entered (or default values of 760mm Hg or 70°F).
   a. To enter a different pressure or temperature value, use the number keys, then press "Enter". The barometric pressure must be between 500 and 800 (mm Hg) and the temperature must be between 50 and 104 (°F). Enter three digits (i.e. 50°F = 050). If not entered correctly the last allowable value or the default value will be displayed, and this step will have to be repeated.
   b. To accept the displayed temperature or pressure value, press "Enter".
4. Enter and zero the Function Code. Any pressure or temperature selected above will appear briefly on the display as well as any other special functions that were selected. They appear again if you enter a new function. To check which functions are in effect, press "Enter". The special function LED will also be lit if special functions are in effect.

NOTE: Once a gas correction factor is entered, all tests will use that factor. To get back to default values on all special functions at once, press "0", "9" and then "Enter".

C. END-OF-BREATH AND START-OF-BREATH DELAYS AND BREATH TRIGGERING LEVELS

FIG.6.1 WAVEFORMS WITH TRIGGER POINTS



A = Without Test Lung
B = With Test Lung
C = With Test Lung and Inspiratory Hold Mode Ventilator

1 = Start of Breath Detected
2 = Common Ventilator Noise
3 = Start-of-Breath Delay Ends
4 = Peak Detected
5 = End of breath detected
6 = End-of-Breath Delay Ends

The RT-200 senses the start of a breath when the flow/pressure reaches 1% of the full scale of the function being used (Fig 6.1, Item 1). This 1% is called the triggering level. It can be raised to 4% (see following page).

The RT-200 ignores pneumatic noise for the first .05 second after the breath is sensed (3). This .05 second is called the "start-of-breath delay" and is intended to prevent nuisance readings created by ventilator valve noise (2). If the RT-200 detects noise after the start-of-breath delay, it will display a "HELP r" message, then automatically "tries again" in case the noise was caused by a vibration in the test set-up or other such irregular disturbances. If the breath delay is longer than the inspiratory time, the "HELP r" message will be displayed (see page 7-2).

The end of a breath is sensed when the flow/pressure drops below the trigger level (5). The RT-200 ignores pneumatic noise for the first .100 second after the breath ends (6). This .100 second is called the "end-of-breath delay" and it is intended to prevent nuisance readings created by ventilator valve noise. If the RT-200 detects noise after the end-of-breath delay, it displays the "HELP F" message, then automatically "tries again" in case the noise was caused by a vibration in the test set-up or other irregular disturbances. If the breath delay is longer than the expiratory time, the "HELP F" message is displayed.

All computations, except for peak measurements, include data from the start-of-breath to the end-of-breath, including the the start-of-breath delay time. Peak measurements are ignored during the start-of breath delay.

Changing the Start-Of-Breath and End-Of Breath Delays and the Triggering Levels:

WARNING: DO NOT use the delays to allow malfunctioning equipment to pass testing. Investigate and solve and abnormal noise!

If changes are made while testing is in progress, testing will resume after the change.

1. Press the "0" and "1" keys, then press "Enter". The current start-of-breath delay will be displayed, Ex: r050. (The "r" stands for the "rising" side of the breath. 050 represents .05 second.)
2. To accept the displayed "rise" delay, press "Enter" and skip the next step.
3. To change the delay time, enter a time between .000 and .200 using the number keys (enter three digits). Then press the Enter key. If not entered properly, the last allowable value or the default value will be displayed, and this step must be repeated.
4. After the start-of-breath delay is properly entered, the current end-of-breath delay time will be displayed. EX: F100. The "F" in the display indicates the falling side of the breath.
5. To accept the displayed "fall" delay, press "Enter" and skip the next step.
6. To change the end-of-breath delay, enter a time between .000 and .200 second using the number keys (enter three digits). Then press the enter key. If not entered properly, the last allowable value or the default value will be displayed, and this step must be repeated.
7. When the end-of-breath is properly entered, "L LO" will appear on the display. This indicates that the start- and end-of-breath is detected at 1% of the full scale of the function being used.
8. To use the displayed trigger value, press enter and skip the next step.
9. To use a 4% trigger value, press any number key. "L HI" will appear on the display. Press "Enter" to accept or any number key to get back to "L LO". (NOTE: For Function Codes 41-48, the triggering points are about 1.8 lpm and 7.2 lpm.)
10. Enter and "zero" the Function Code. All the applicable functions will appear briefly on the display. They will appear again if a new Function Code is entered. To check which functions are in effect, press "Enter". The special function LED will also be lit if special functions are in effect.

NOTE: If the start-of-breath delay is too short a "HELP r" message appears. If the end-of-breath delay is too short a "HELP F" message appears. Following these messages, the RT-200 automatically "tries again" in case the error message was caused by an external disturbance of the test set up.

7. USER TROUBLESHOOTING AND HELP MESSAGES

If you encounter a problem not addressed here, call Timeter and ask for "RT-200 Service." Call (800) 233-0258. In Pennsylvania, call COLLECT (717) 569-2695.

TABLE 7.1 USER TROUBLESHOOTING CHART

SYMPTOM	CAUSE	SOLUTION
Nothing happens when Peak/Continuous key pressed	Peak/Continuous not available in this function	
Underrange lamp lit	Connections loose at RT-200 inlet	Tighten
	Display reading below -10	
	Negative flow exists	Do not attach vacuum
Screen goes blank, with Overrange lamp lit	Overrange window exceeded	Change to High Range Inlet
Display is dark, no function indicator lamps lit	System not plugged in	Plug system in.
	System not turned on	Turn system on. Power switch is on rear of control module.
	Fuse blown	Unplug power cord. Replace fuse with same type and rating.
	Hardware fault	See Control Module troubleshooting chart.
Display shows strange characters or no characters.	System error caused by power line transient or static electricity.	Turn power off, wait 2 seconds, then turn power on again.
		Check for proper grounding
	Hardware fault	See Control Module troubleshooting chart.
Display will not change	RT-200 in peak-detect mode	Press Peak/Continuous key.
	System error caused by power line transient or static electricity	Turn power off, wait 2 seconds, then turn power on again.
		Check for proper grounding
	Hardware fault	See Control Module troubleshooting chart.
RT-200 doesn't respond to keypad commands	System error caused by a power line transient or static electricity	Turn power off, wait 2 seconds, then turn power on again.
	Hardware fault	See Control Module troubleshooting chart.

Table 7.1 User Troubleshooting Chart (continued)

SYMPTOM	CAUSE	SOLUTION
False low readings on low flow fate functions	Flow passing through high flow transducer	Remove hose from high flow range inlet.
	Low flow outlet blocked	Free the low flow outlet.
	Hardware fault	See Control Module troubleshooting chart.
False Readings on low or high flow rate or volume	Cap was left on outlet	Remove.
	Using wrong function for test gas	Select proper function. Enter proper oxygen %.
	Using wrong gas correction for test gas	Select ATP, BTPS, STP as needed
	Hardware fault	See Control Module troubleshooting chart.
	Leaks in test set up	Fix leaks
	Equipment being tested is affected by test set-up, incorrect test lung, etc.	Refer to the Manuals of the equipment being calibrated, for proper test "loads"
Inaccurate Readings	Zero drift	Rezero the RT-200
	Hose/ventilator valve noise	Don't bump tubing, see Chapter 6, section C
	Using improper gas correction factor	Consult manufacturer's specs. See page 6-2.

Table 7.2 HELP MESSAGES:

Various error conditions can occur that bring "HELP" messages to the display. These messages give an indication of the problem's cause. The messages which may occur, along with their meanings, are listed below:

Display Message	Meaning
HELP o	Zero key was pushed while there was flow or pressure applied to the RT-200. Remove the source of flow or pressure and restart the zeroing by pressing the Zero key again.
HELP E	A computational error occurred in the RT-200. This message should never occur. If it does, document the conditions that led to it and call Timeter.
HELP r	Difficulty triggering at start of a cycle. Ventilator noise occured after start-of-breath delay. See Chapter 6, section C.
HELP F	Difficulty triggering at end of a cycle. Ventilator noise occured after end-of-breath delay. See Chapter 6, section C.

MAINTENANCE INSTRUCTIONS

Since the RT-200 System is a precision device used for the calibration and testing of other equipment and due to highly specialized nature of the equipment and techniques required to recalibrate the RT-200 System, repairs that can effect the accuracy of the RT-200 will NOT be described in this manual!

As an aid to maintenance, troubleshooting and repair, "Assembly Pictorials With Part Numbers" have been included (see chapter 11). These pictorials are helpful in removing and replacing parts. Special instructions are provided for replacement of EPROMS (see chapter 14) and other static sensitive components.

8. THEORY OF OPERATION

The RT-200 theory of operation is explained with the aid of a block diagram (Fig.8.1) that shows the RT201M Control Module, RT202 Pressure Module, RT203 Flow Module and the Module Interconnect Bus. The block diagram identifies the major assemblies of the system, describes their functions, and gives their physical locations in the equipment with reference designations. More detailed breakdowns of the assemblies are provided in the assembly pictorials and parts list elsewhere in this manual.

A. RT201M THE CONTROL MODULE

The RT201M Control Module (A1) contains the microprocessor-based System Controller PCB (printed circuit board) assembly, the Keyboard/Display PCB assembly, the Power Supply system and it is the origin of the Module Interconnect Bus. The functions of these components are described below.

1. The System Controller PCB assembly (A1A3A1) consists of a microprocessor, memory devices and peripheral devices that control system operation and send and receive data to the RT202 Pressure and RT203 Flow Modules and to the Keyboard/Display PCB assembly.

   EPROM memory integrated circuits (IC's) A1A3A1-U1 through U6 are used to store the operating system (microprocessor software) as well as calibration constants tailored to the other modules in the system (all modules must have the same serial number).

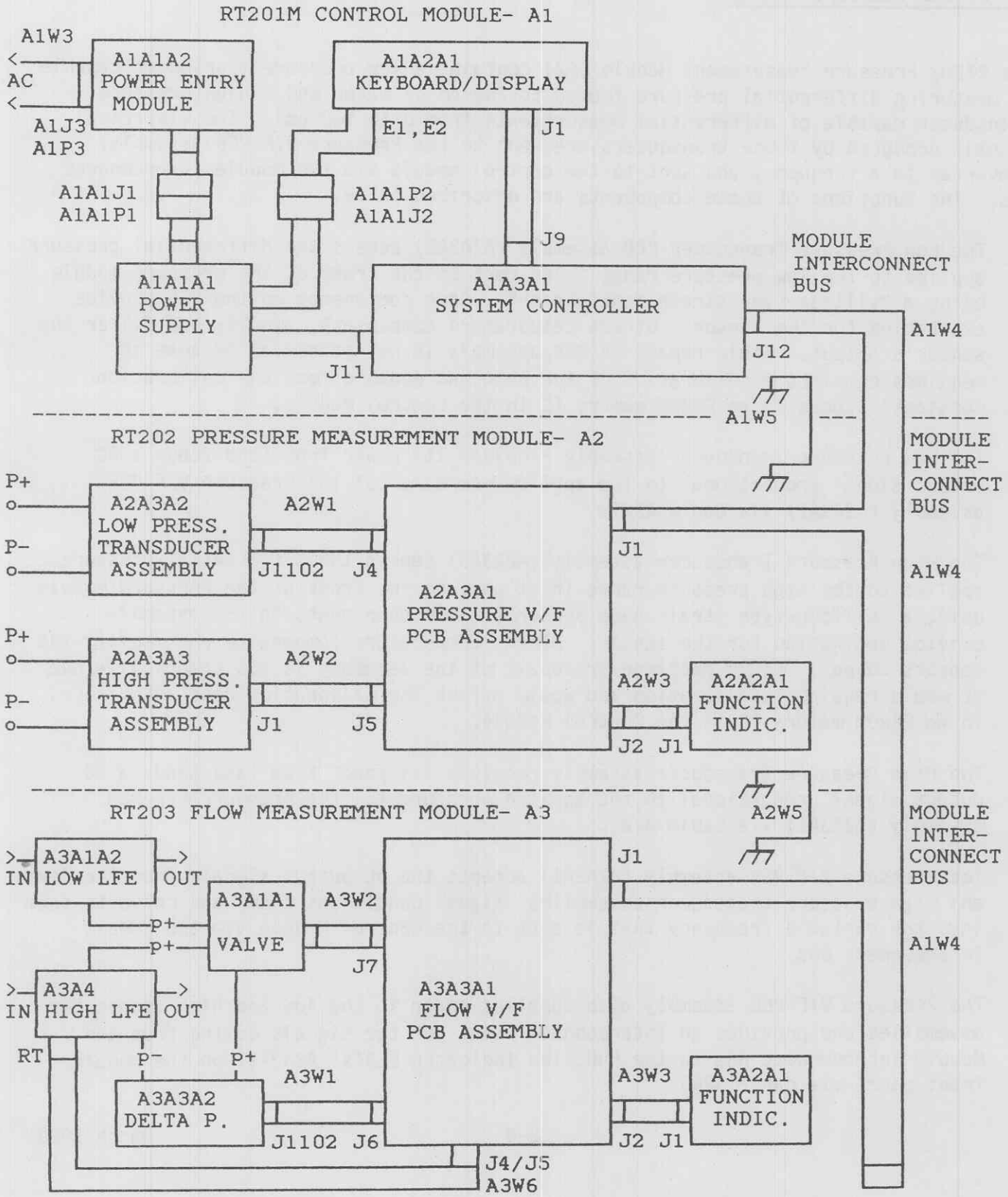
   The measurement data from the Pressure and Flow Modules is sent to the System Controller through the Module Interconnect Bus in the form of a variable frequency square wave in the range of approximately 1500 to 9500 Hz. The System Controller PCB assembly digitizes this information so it can be processed, linearized per the EPROM data and displayed via the Keyboard/Display PCB assembly.

2. The Keyboard/Display PCB assembly (A1A2A1) contains a 16-position keyboard, five 7-segment LED displays and associated keyboard and display circuitry. It is controlled by a dedicated peripheral on the System Controller PCB via a ribbon cable and transition connnector J1. A direct connection to the power supply is provided via points E1 and E2 and connector A1A1P2.

3. The Power Supply system consists of a Power Inlet Module (A1A1A2) which includes a power switch, fuses, voltage selector switch, RFI filter and transient voltage suppressor, and a linear power supply (A1A1A1) that produces +5VDC and $\pm$ 15VDC.

FIG.8.1

RT-200 SYSTEM BLOCK DIAGRAM



B. RT-202 PRESSURE MODULE

The RT202 Pressure Measurement Module (A2) contains a low pressure transducer capable of measuring differential pressure from 0 to 250 cm of water and a high pressure transducer capable of differential measurements from 0 to 100 psi. The electrical signals produced by these transducers are sent to the Pressure V/F PCB assembly, converted to a frequency and sent to the control module via the Module Interconnect Bus. The functions of these components are described below.

1. The Low Pressure Transducer PCB assembly (A2A3A2) senses the differential pressure applied to the low pressure range inlet port on the front of the pressure module using a "silicon-type strain gage sensor". Some components on the PCB provide excitation for the sensor. Others temperature compensate, amplify and filter the sensor's output. Field repair of the assembly is not practical because it requires complete recalibration of the unit and would effect the calibration constants stored in an EPROM memory IC in the Control Module.

   The Low Pressure Transducer assembly receives its power from (and sends a DC output signal proportional to the applied pressure to) the Pressure V/F PCB assembly (A2A3A1) via cable A2W1.

2. The High Pressure Transducer assembly (A2A3A3) senses the differential pressure applied to the high pressure range inlet port on the front of the Pressure Module using a "silicon-type strain gage sensor". Some components in the assembly provide excitation for the sensor. Others temperature compensate and amplify the sensors output. Field exchange or repair of the assembly is not practical since it would require recalibration and would effect the calibration constants stored in an EPROM memory IC in the Control Module.

   The High Pressure Transducer assembly receives its power from (and sends a DC output signal proportional to the applied pressure to) the Pressure V/F PCB assembly (A2A3A1) via cable A2W2.

3. The Pressure V/F PCB assembly (A2A3A1) accepts the DC output signals from the low and high pressure transducer assemblies, signal conditions them, and converts them into the variable frequency that is sent to the Control Module via the Module Interconnect Bus.

   The Pressure V/F PCB assembly also supplies power to the low and high transducer assemblies and provides an interconnect point for the signals coming from the Module Interconnect Bus to the Function Indicator LED's (A2A2A1) on the module front panel via cable A2W3.

C. RT203 FLOW MODULE

Th RT203 Flow Measurement Module (A3) is capable of measuring low range flow rates from 0 to 5 liters per minute (lpm), and high range flow rates from 0 to 180 lpm. Flow rate measurements are accomplished by measuring the differential pressure drop (Delta) across the low or high range laminar flow elements. Pressure signals from the laminar flow elements are sent through a selector valve to the Flow Delta Pressure PCB assembly, converted to a DC voltage, sent to the Flow V/F PCB assembly where they are converted to a frequency and sent to the Control Module via the Module Interconnect Bus.

The volume, rate/time, gas correction functions etc. on the RT203 Flow Module are all accomplished in the software of the Control Module using flow signals derived from the Laminar Flow Elements. The functions of these components are described below.

1. The low and high range flow rate measurements are made by measuring the pressure drop across the Low Range Laminar Flow Element (A3A1A2) or the High Range Laminar Flow Element (A3A4). Laminar flow elements are devices that produce a linear pressure drop with respect to flow rate. The differential pressure signals from the Laminar Flow Elements are sent though the Selector Valve (A3A1A1) to the Flow Delta Pressure PCB assembly (A3A3A2).

   Since only one differential pressure measuring device exists in the Flow Module, and because the Flow Flow Range Laminar Flow System uses one of the pressure connections on the High Range Laminar Flow Element for a pressure reference, THE LOW FLOW RANGE CANNOT BE USED WHEN THERE IS ANY FLOW PASSING THROUGH THE HIGH FLOW ELEMENT OR MEASUREMENT ERRORS WILL RESULT!

   The Low Range Laminar Flow Element (A3A1A2) receives test gas from the low flow range inlet port on the front of the module and releases the gas to atmosphere through the back of the module. Provisions for nitrous oxide scavenging are provided through the use of a bracket and external equipment (see page 5-5).

   The High Range Laminar Flow Element (A3A4) receives test gas from the high flow range inlet port on the front of the module and releases the gas to atmosphere (unless tubing is attached) through the back of the module. If there is any external restriction at the outlet during flow or volume measurements, the measurement will have to be adjusted (see "OPERATIONAL CONSIDERATIONS" section D).

2. The Flow Delta Pressure PCB assembly (A3A3A2) senses the differential pressure produced by the Laminar Flow transducer using a "silicon-type strain gage sensor". This sensor is mounted on the PCB assembly and connected by flexible tubing to the high or low range laminar flow transducer via the Selector Valve. Some components on the PCB provide excitation for the sensor. Others temperature

compensate, amplify and filter the sensor's output. Field repair of the assembly is not practical because it would require complete recalibration and would effect the calibration constants stored in an EPROM memory IC in the Control Module.

The Flow Delta Pressure PCB assembly receives its power from (and sends a DC output signal proportional to the applied flow to) the Flow V/F PCB assembly (A3A3A1) by way of cable (A3W1).

3. The Flow V/F PCB assembly A3A3A1 accepts the DC output signal from the Flow Differential Pressure PCB assembly. It conditions this signal and converts it into the variable frequency that signals the Control Module via the Module Interconnect Bus.

   The V/F assembly also accepts gas temperature information from 2 thermistors (variable resistance temperature sensors) by way of connectors J4 and J5 and cable A3W6. This information allows the flow rate to be compensated based on the temperature of the gas in the High Flow Laminar Element.

   The Flow V/F PCB assembly also:
   - supplies power to the Flow Differential Pressure assembly.
   - provides an interconnect point for the signals coming from the Module Interconnect Bus to the Function Indicator LED's (A3A2A1) mounted on the front panel by way of a cable (A3W3).
   - contains the circuitry needed to control the Selector Valve by way of a cable (A3W2).

D. MODULE INTERCONNECT BUS

1. The Module Interconnect Bus is a 26-conductor ribbon cable (A1W4) that connects the Control Module and the Pressure and Flow measurement modules. Its purpose is to supply power to the measurement modules, allow the Control Module to send signals to the measurement modules to control their operation, and allow pressure, flow etc. data to be sent from the measurement modules back to the Control Module.

   Table 8.1 and Table 8.2 list the Bus pin number, the description of the signal on the Bus pin and the signal state when various functions are selected.

Cables A1W5 and A2W5 also interconnect the modules. These single conductor cables ensure a good grounding bond between the modules.

TABLE 8.1 MODULE INTERCONNECT BUS

Bus Pin #	Signal	Voltage/Signal Description Under Conditions Stated	Present
1	-15VDC Power Source	-15.2VDC ± .2 VDC	Always
2	+15VDC Power Source	+15.2VDC ± .2 VDC	Always
3	Spare	N/A	
4	+ 15VDC Power Return	OVDC	Always
5	Function Select- V2	See Table 8.2	
6	LED Select-L3	See Table 8.2	
7	Function Select-V1	See Table 8.2	
8	LED Select-L4	See Table 8.2	
9	Spare	N/A	
10	LED Select-L8	See Table 8.2	
11	Function Select-M1	See Table 8.2	
12	LED Select-L7	See Table 8.2	
13	Function Select M2	See Table 8.2	
14	LED Select-L6	See Table 8.2	
15	Function Select-M3	See Table 8.2	
16	LED Select-L5	See Table 8.2	
17	Function Select-M4	See Table 8.2	
18	LED Select-L1	See Table 8.2	
19	Function Select-M5	See Table 8.2	
20	LED Select-L2	See Table 8.2	
21	Function Select-M6	See Table 8.2	
22	+5VDC RETURN	OVDC	Always
23	Module Signal Output	1.5-9.5 KHz Square wave when module enabled	
24	Spare	N/A	
25	Aux Control Line (Spare)	N/A	
26	+5 VDC Source	+5.0 VDC ± .2VDC	Always

TABLE 8.2 FUNCTION AND LED SELECT LINE VOLTAGE LEVEL vs. FUNCTION SELECTED

"0" represents a 0.4 ± .4 VDC measurement.
"5" represents a 4.0 ± 1 VDC measurement.

FUNCTION NUMBER	FUNCTION SELECT LINE								LED SELECT LINE							
REF #	M1	M2	M3	M4	M5	M6	V1	V2	L1	L2	L3	L4	L5	L6	L7	L8
PIN #	11	13	15	17	19	21	7	5	18	20	6	8	16	14	12	10
10	5	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5
11	5	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5
12	5	0	0	0	0	0	0	0	5	0	5	5	5	5	5	5
13	5	0	0	0	0	0	0	0	5	5	0	5	5	5	5	5
20	0	5	0	0	0	0	0	0	5	5	5	5	0	5	5	5
21	0	5	0	0	0	0	0	0	5	5	5	5	0	5	5	5
22	0	5	0	0	0	0	0	0	5	5	5	5	5	0	5	5
23	0	5	0	0	0	0	0	0	5	5	5	5	5	5	0	5
30	0	0	5	0	0	0	0	0	0	5	5	5	5	5	5	5
31	0	0	5	0	0	0	0	0	0	5	5	5	5	5	5	5
32	0	0	5	0	0	0	0	0	5	0	5	5	5	5	5	5
33	0	0	5	0	0	0	0	0	5	5	0	5	5	5	5	5
35	0	0	5	0	0	0	0	0	5	5	5	5	0	5	5	5
36	0	0	5	0	0	0	0	0	5	5	5	5	5	0	5	5
37	0	0	5	0	0	0	0	0	5	5	5	5	5	5	0	5
40	0	0	0	5	0	0	0	0	5	5	5	5	0	5	5	5
41	0	0	0	5	0	0	0	0	5	5	5	5	0	5	5	5
42	0	0	0	5	0	0	0	0	5	5	5	5	5	0	5	5
43	0	0	0	5	0	0	0	0	5	5	5	5	5	5	0	5
45	0	0	0	5	0	0	0	0	0	5	5	5	5	5	5	5
46	0	0	0	5	0	0	0	0	5	0	5	5	5	5	5	5
47	0	0	0	5	0	0	0	0	5	5	0	5	5	5	5	5
48	0	0	0	5	0	0	0	0	5	5	5	0	5	5	5	5

SEE NOTES ON FOLLOWING PAGE!

NOTE 1: The LED Select Lines determine which LED on the measurement module lights to indicate what function, if any, has been selected by the operator. The lines are all at +4VDC $\pm$ 1 VDC, except for the one line activating the LED that will be at 0.4 VDC $\pm$ .4 VDC, (all with respect to the +5V return).

NOTE 2: The Function Select Lines determine which function, if any, on the measurement modules has been selected by the operator. The lines are all at 0.4 VDC $\pm$ .4 VDC, except for the one line activating the function that will be at +4 $\pm$ 1 VDC (all with respect to the +5 return).

NOTE 3: Function Select Lines V1 and V2 are normally at 0 VDC except for a 50 msec $\pm$ 10 msec positive pulse when the valve is switching (V1 is the pulse that is sent to select HIGH Flow; V2 selects LOW Flow).

9. ROUTINE MAINTENANCE

The schedule below is based on typical usage. The user is responsible for final determination of periods based on: accuracy required, care given to ensure use of clean, dry gas, proper storage and proper usage.

TABLE.9.1 ROUTINE MAINTENANCE SCHEDULE

PERIOD	ACTION	SPECIAL
WEEKLY	Replace broken or missing items	See assembly pictorials and parts lists to identify parts that may be changed without effecting calibration.
YEARLY (Or as required)	Check Accuracy of Calibration*	Procedures depend on the equipment available. Should include a 10%, 50%, 100% of full scale check on all ranges.
	Check AC Current Leakage, 100 ua maximum	Use standard leakage current test procedures (ref Underwriters Lab specification UL-544).
30 Months	Return Unit To Timeter For Recalibration	Recalibration requires special equipment, includes disassembly for cleaning of LFE's, electrical adjustments and new EPROM calibration factors.

* See Recalibration Statement, Appendix A.

10. SCHEMATICS AND TROUBLESHOOTING CHARTS

Consult the "USER TROUBLESHOOTING" section of this manual to eliminate the possibility of an application error before using the following troubleshooting instructions. If the following troubleshooting charts do not isolate the fault, return the RT-200 to Timeter for repair. It will be necessary in most cases to return the entire RT-200 system even though only one module appears to be malfunctioning. Recalibration following repair usually involves all three modules.

IMPORTANT CAUTIONS

- DO NOT SWAP MODULES BETWEEN DIFFERENT RT-200 SYSTEMS! Only Modules having the same serial number as the Control Module will function properly. This applies to the calibration EPROMS (A1A3A1 U1-U6).

- Any repairs made to the RT-200 system should be followed by a calibration verification to ensure proper operation before returning the RT-200 to service (see ROUTINE MAINTENANCE").

- Replacement of parts must be done with the same part number, type, length, etc. as originally installed or safety of operation and accuracy may be affected.

- DO NOT remove the Ground Bonding Cables (A1W5 and A2W5) while the Module Interconnect Bus Cable A1W4 is still connected, or damage due to static electricity may result to the components on the printed circuit boards!!

- Always install the A1W5 and A2W5 Ground Bonding Cables BEFORE the A1W4 Module Interconnect Cable is installed. Leave the Ground Bonding Cables on until AFTER the Module Interconnect Cable is removed. This applies whether or not the RT-200 is energized.

- Removal of the Control Module top cover and/or separation of the Pressure or Flow Modules from the Control Module may be required for some of the following diagnostic and replacement procedures. Refer to the assembly pictorials and Parts List for assembly information and part numbers for replacement items.

- Replacement of pneumatic components (tubing, etc) must be done with the same type and length as originally used. Because special techniques may be required to install and check components after installation, contact the Timeter Repair Shop before changing pneumatic components.

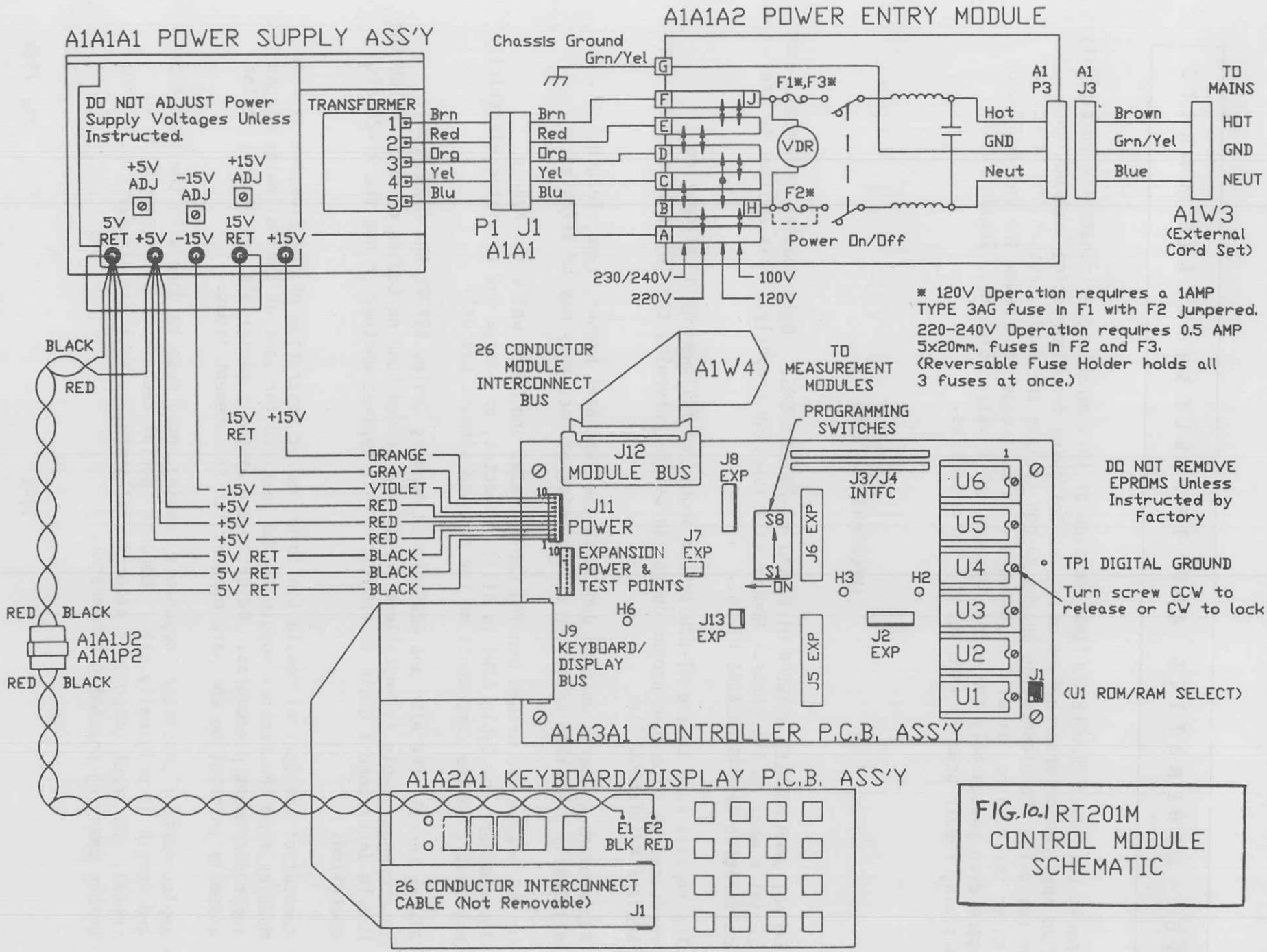


FIG. 10.1 RT201M CONTROL MODULE SCHEMATIC

TABLE.10.1 CONTROL MODULE TROUBLESHOOTING CHART

SYMPTOM	PROBABLE CAUSE	CORRECTIVE MEASURE
NO DISPLAY OR VALVE CLICK WHEN POWER TURNED ON	No Power at Outlet Cordset detached/ defective	Restore Power Plug in or replace cordset
	Fuse blown/Improper Line Voltage Selection	Replace fuses, check proper AC voltage selection (INSTALLATION INSTRUCTIONS).
	Internal connector detached/not seated	Inspect and Remedy
	Power Inlet Module faulty (A1A1A2)	Check for 120VAC ± 10 VAC between power transformer terminals 1 and 3 on the A1A1A1 assembly, if not present, check wiring, then replace the Power Inlet Module.
	Power Supply (A1A1A1) Faulty or External Power Supply Short	Check the +5VDC, +15VDC and -15VDC outputs of the power supply (see Control Module schematic). If they cannot be adjusted to ± .2VDC of their nominal values, replace the Power Supply assembly or detach load and locate short.
NO DISPLAY WHEN POWER TURNED ON, BUT VALVE CLICK HEARD	Internal connector detached/not seated	Inspect and remedy.
	Defective keyboard/ display assembly A1A2A1	Replace keyboard/display assembly.
DISPLAYS E _ _ ON POWER UP, BUT A DISPLAY SEGMENT IS MISSING	Internal connector detached/not seated	Inspect and remedy
	Defective keyboard/ display assembly A1A2A1	Replace keyboard/display assembly
DISPLAY APPEARS GARBLED ON POWER UP OR DURING OPERATION	Loose internal connector.	Inspect and remedy.
	Power line ground thru AC power cord missing or modules don't have good ground bonds.	Inspect and remedy missing ground, check bonding jumpers A1W5, A2W5.
	IC/EPROM on the System Controller PCB not seated properly.	Inspect and remedy, see "GENERAL INFORMATION", 14-1.
	Defective keyboard/ display assembly A1A2A1.	Replace keyboard/display assembly.

CONTINUED

TABLE.10.1 CONTROL MODULE TROUBLESHOOTING CHART (continued)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE MEASURE
DISPLAYS E _ _ ON POWER UP, BUT ONE OR MORE KEYS DON'T FUNCTION	Internal connector detached/not seated	Inspect and remedy.
	Binding key(s)	Loosen screws holding Keyboard/Display Assembly to panel and recenter switches in cut-outs
	Defective Keyboard/ Display assembly A1A2A1.	Replace keyboard/display.
DISPLAY/KEYBOARD OPERATE, BUT A PRESSURE OR FLOW MEASUREMENT PROBLEM EXISTS	Module Interconnect Cable A1W4 disconnected or malfunctioning.	Inspect and remedy.
	Malfunction exists in Pressure/Flow Module	Troubleshoot Pressure or Flow Module (see separate troubleshooting charts).

TABLE 10.2 PRESSURE MODULE TROUBLESHOOTING

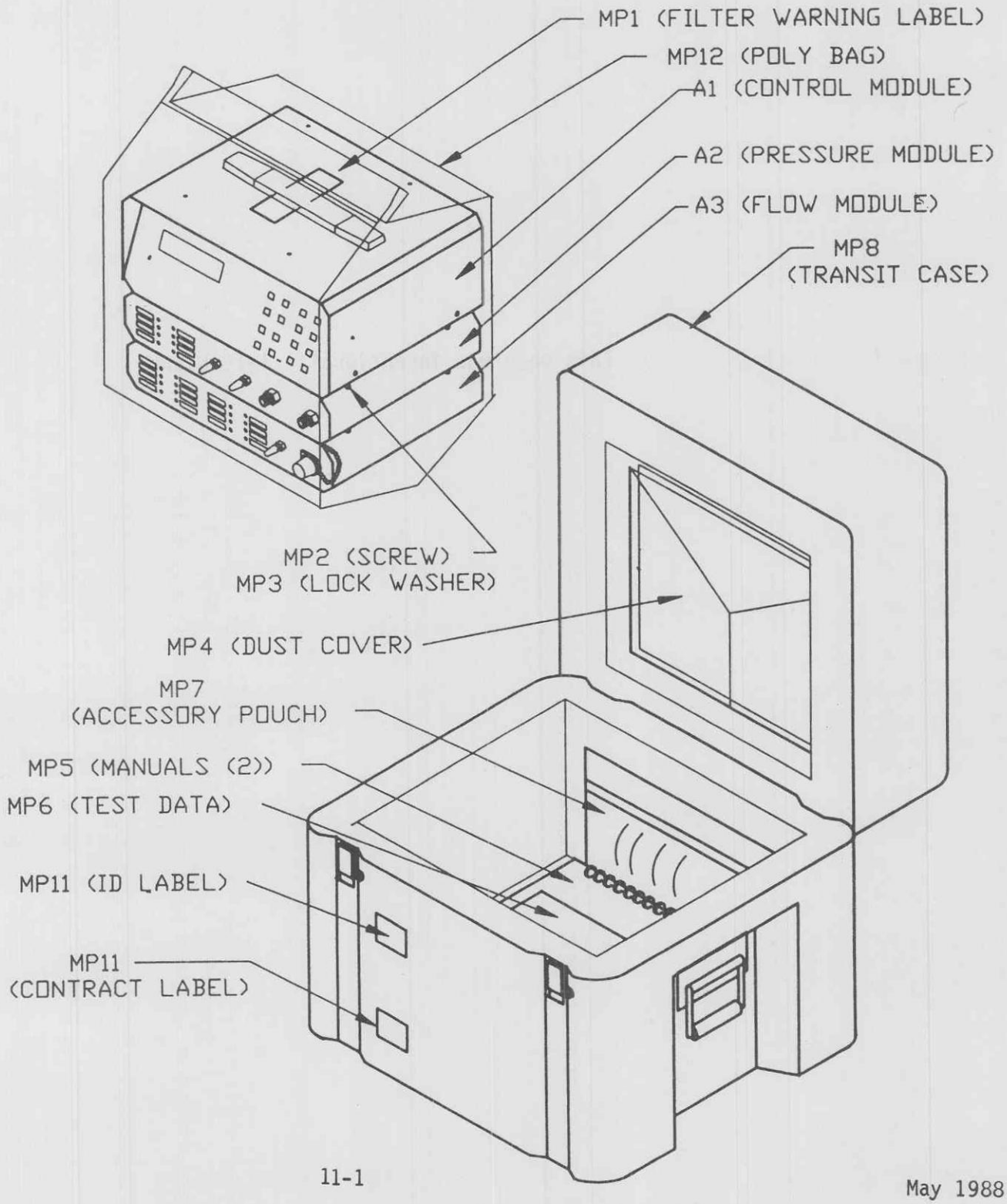
SYMPTOM	PROBABLE CAUSE	CORRECTIVE MEASURE
PRESURE MODULE FUNCTION(s) ARE INOPERATIVE OR INACCURATE	Leaks in tubing outside Pressure Module	Inspect and remedy
	Internal connector detached/not seated	Inspect and remedy
	Module Interconnect Cable A1W4 is disconnected/ malfunctioning	Inspect and remedy
	Pressure Module Needs repair and/or recalibration	Return RT-200 System to Timeter
"HELP 0" ON DISPLAY WHEN ZEROING LOW PRESSURE RANGES	Excessive "ZERO DRIFT" in Low Pressure transducer or associated circuitry.	Select Function "10" to see 1/4 sec sample of frequency out of V/F converter. If not between 250 - 500: ADJUST ONLY THE POTS INDICATED - OTHER ADJUSTMENTS WILL DISTURB CALIBRATION!!! a) With voltmeter between A2A3A1 TP3 HI, TP13 LO, adjust pot R1102 on the A2A3A2 assembly so meter reads 0 + .005VDC. b) Adjust pot R38 on the A2A3A1 assembly so the RT-200 display reads 375 + 10.
"HELP 0" ON DISPLAY WHEN ZEROING HIGH PRESSURE RANGES	Excessive "ZERO DRIFT" in High Pressure transducer or associated circuitry.	Select Function "20" to see 1/4 sec sample of frequency out of the V/F converter. If not between 250 - 500: ADJUST ONLY THE POTS INDICATED - OTHER ADJUSTMENTS WILL DISTURB CALIBRATION!!! a) Adjust pot R39 on the A2A3A1 assembly so the RT-200 display reads 375 + 10.

TABLE.10.3 FLOW MODULE TROUBLESHOOTING CHART

SYMPTOM	PROBABLE CAUSE	CORRECTIVE MEASURE
FLOW MODULE FUNCTION(s) ARE INOPERATIVE OR INACCURATE	Leaks outside Flow Module	Inspect and remedy
	Leak in External O-rings on High Flow Ranges	Replace O-rings
	Flow Outlets blocked	Inspect and remedy
	Internal connector detached/not seated	Inspect and remedy
	Module Interconnect Cable A1W4 disconnected/ or malfunctioning	Inspect and remedy
	High/Flow Range LFE's are dirty.	Return RT-200 system to Timeter.
	Flow Module Requires Repair or Recalibration	Return RT-200 system to Timeter.
	Low Flow Range errors due to flow through High Range Inlet	Disconnect all High Flow Range external tubing when using Low Flow ranges.
"HELP 0" ON DISPLAY WHEN ZEROING ANY FLOW MODULE RANGES	Excessive "Zero Drift" in DELTA P transducer or associated circuitry	Select Function "30" to see 1/4 sec sample of frequency out of the V/F converter. If not between 250 - 500: ADJUST ONLY THE POTS INDICATED - OTHER ADJUSTMENTS WILL DISTURB CALIBRATION. a) With Voltmeter between A3A3A1 TP4 HI, TP2 LO, adjust pot R1102 on the A3A3A2 assembly so meter reads 0 $\pm$ .005VDC. b) Adjust pot R33 on the A3A3A1 assembly so the RT-200 display reads 375 + 10.

11. ASSEMBLY PICTORIALS WITH PART NUMBERS

FIG.11.1 RT-200 SYSTEM ASSEMBLY PICTORIAL



A. RT-200 SYSTEM PARTS LIST

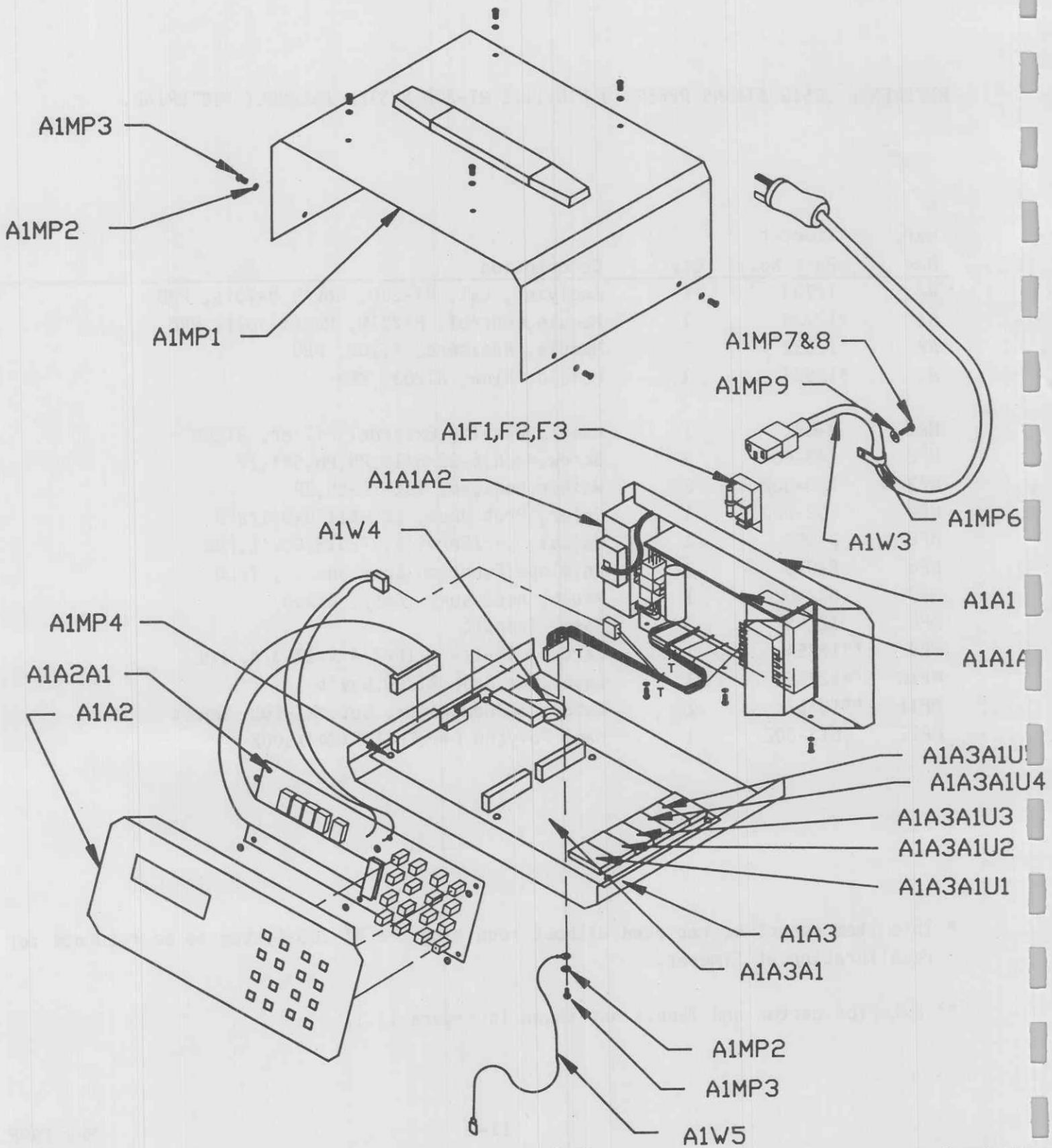
REFERENCE DESIGNATIONS REFER TO FIG.11.1 RT-200 SYSTEM ASSEMBLY PICTORIAL.

Ref. Des.	Timeter Part No.	Qty	Description
--	12703	1	Analyzer, Cal, RT-200, Gov't,M-Volt, PRD
A1	*12724	1	Module,Control, RT201M, Multi-Volt, PRD
A2	*12632	1	Module, Pressure, RT202, PRD
A3	*12633	1	Module, Flow, RT203, PRD
MP1	P-021	1	Label, Warning,External Filter, RT200
MP2	740-604	8	Screw,Mach,6-32x5/16,PN,PH,Stl,ZP
MP3	730-002	8	Washer,Lock,#6, Int Teeth,ZP
MP4	602-003	1	Cover, Prot Dust, 12"WX11"DX9-1/2"H
MP5	D-098	2	Manual,Oper/Service,RT201M,Gov't,PRD
MP6	P-059	1	Envelope,Function Spec Sheets,RT200
MP7	002-021	1	Pouch, Accessory, Assy, RT200
MP8	12755	1	Case, Transit
MP9	**12754	1	Carton, 17-1/4 x 16-1/4 x 17-3/4, FOL
MP10	**12756	1	Label,Bar Code,RT200,Gov't
MP11	**12757	2	Label, ID/Contract#, Set, RT-200, Gov't
MP12	613-002	1	Bag, Polythn,Clr,FL,14"X24"X.002

* This item cannot be replaced without requiring the RT-200 System to be returned for recalibration at Timeter.

** Exterior carton and labels not shown in Figure 11.1.

FIG.11.2 CONTROL MODULE ASSEMBLY PICTORIAL



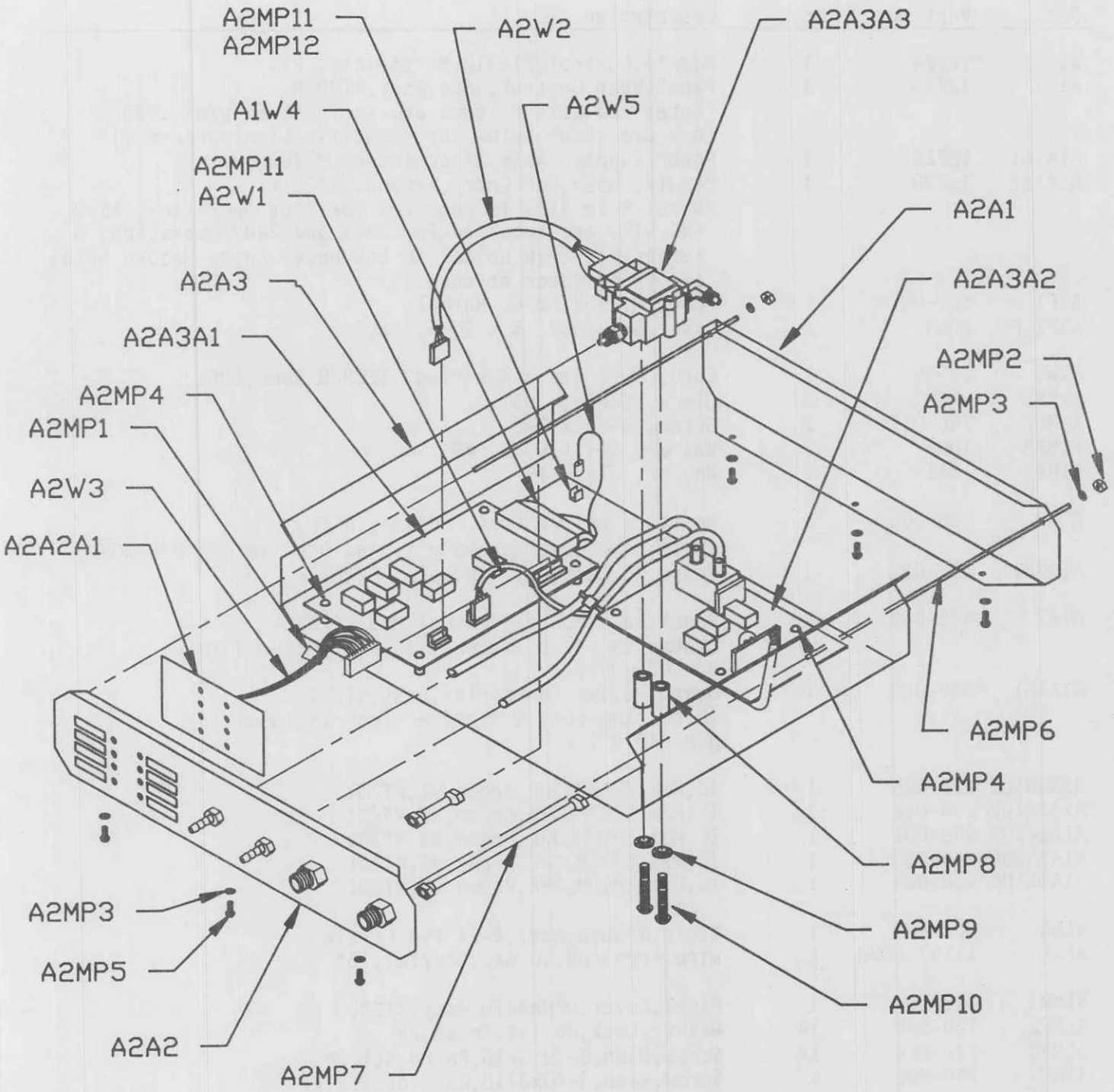
B. CONTROL MODULE LEVEL PARTS LIST

REFERENCE DESIGNATIONS REFER TO FIG.11.2 CONTROL MODULE ASSEMBLY PICTORIAL.

Ref. Des.	Timeter Part No.	Qty	Description
A1	*12724	1	Module,Control,RT201M,Multi-Volt, PRD
A1A1	12725	1	Panel,Rear,Control, Mod,Assy,RT201M (Note: the next 9 items are included in p/n 12725; they are shown below for identification purposes.)
A1A1A1	12726	1	Power Supply, Assy,W/connectors,RT201M
A1A1A2	12728	1	Module, Assy,Pwr Entry,W/Conn.,RT201M (Note: Fuse A1F1 is required for 120V operation, A1F2 and A1F3 are required for 220V and 240V operation, a reversible fuse holder in the Power Entry Module holds all three fuses at once.)
A1F1	503-001	1	Fuse,1A,250V, 3AG, Normal
A1F2,F3	8004	2	Fuse,.5A, 250V, 5 x 20mm, Fast
A1W3	12685	1	Cord, Pwr, Hsp Grade Plug, IEC320 Conn,10ft
A1MP6	0700	1	Clamp, Cable, .0375
A1MP7	740-011	1	Screw, 8-32 x 1/2
A1MP8	1005	1	Washer, Split Lock, #8
A1MP9	1344	1	Washer, Flat, #8
A1A2	025-008	1	Panel, Front,Control Mod,Assy,RT201 (Note: the next assembly is included in p/n 025-008.)
A1A2A1	010-021	1	Board,PC,Assy,Keybd/Display,RT201
A1A3	025-009	1	Panel,Bottom,Assy,Control Mod,RT201 (Note: the next assembly is not included in p/n 025-009).
A1A3A1	*010-020	1	Board,PC,Sys Controller,Assy,RT201 (Note: the next 5 items are not included in p/n 010-020).
A1A3A1U1	258-005	1	IC,Mem,EPROM,32K,Prgmd,U1,RT201
A1A3A1U2	258-002	1	IC,Mem,EPROM,32K,Prgmd,U2,RT201
A1A3A1U3	258-001	1	IC,Mem,EPROM,32K,Prgmd,U3,RT201
A1A3A1U4	*258-003	1	IC,Mem,EPROM,32K,Prgmd,U4,RT201
A1A3A1U5	*258-004	1	IC,Mem,EPROM,32K,Prgmd,U5,RT201
A1W4	008-039	1	Cable,Ribbon,Assy,4-26 Pin Female
A1W5	11157.0073	1	Wire,Prepared,18 Ga.,Grn/Yel,15"
A1MP1	015-004	1	Panel,Cover,w/Handle,Assy,RT201
A1MP2	730-002	14	Washer,Lock,#6,Int.Teeth,ZP
A1MP3	740-604	14	Screw,Mach,6-32x5/16,PN,PH,Stl,ZP
A1MP4	740-002	6	Screw,Mach,4-40x3/16,Rd,Slot,Stl,ZP

* This item cannot be replaced without requiring the RT-200 System to be returned for recalibration at Timeter.

FIG.11.3 PRESSURE MODULE ASSEMBLY PICTORIAL



C. PRESSURE MODULE PARTS LIST

REFERENCE DESIGNATIONS REFER TO FIG.11.3 PRESSURE MODULE ASSEMBLY PICTORIAL.

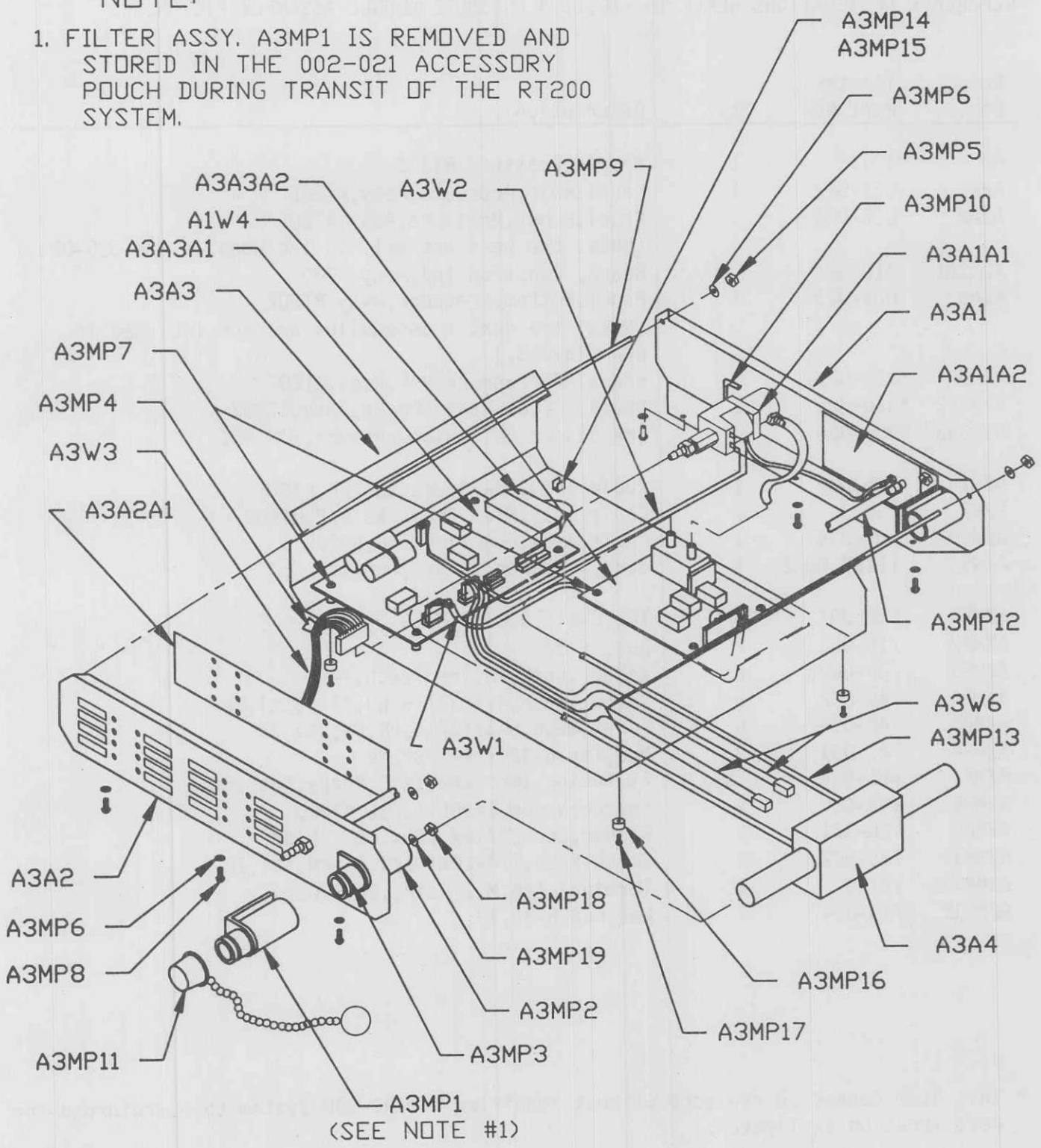
Ref. Des.	Timeter Part No.	Qty	Description
A2	*12632	1	Module,Pressure,RT202
A2A1	025-012	1	Panel,Rear,Pressure,Assy,RT202
A2A2	025-014	1	Panel,Front,Pressure,Assy,RT202 (Note: the next assembly is included in p/n 025-014.)
A2A2A1	010-024	1	Board, Function Ind,Assy,RT202
A2A3	025-013	1	Panel,Bottom,Pressure,Assy,RT202 (Note: the next 3 assemblies are not included in p/n 025-013.)
A2A3A1	*010-022	1	Board,PC,Pressure,V/F,Assy,RT202
A2A3A2	*010-025	1	Board,PC,Low Range Press,Assy,RT202
A2A3A3	*003-006	1	Transducer,Assy,HighPressure,100 PSI
A2W1	008-032	1	Cable Assy,Low Press to V/F,RT202
A2W2	10033	1	Cable Assy,High Press to V/F,RT202
A2W3	008-034	1	Cable Assy,Function Ind,RT202/3
A2W5	11157.0072	1	Wire,Prepared,18 Ga.,Grn/Yel,15"
A2MP1	620-001	5	Tie,Cable,0.09x3.6"LG
A2MP2	710-002	2	Nut, 6-32
A2MP3	730-002	8	Washer,Lock,#6,Int Teeth,ZP
A2MP4	740-002	8	Screw, Mach,4-40x3/16,Rd,Slot,Stl,ZP
A2MP5	740-604	6	Screw,Mach,6-32x5/16,PN,PH,Stl,ZP
A2MP6	747-001	2	Rod,Thd,6-32 x 8-7/8",ZP
A2MP7	911-004	.541	Ft Tubing,Impolene,1/4",Porpy,Nat Wht
A2MP8	609-008	2	Spacer,Nylon,1/20Dx13/16,RT200
A2MP9	726-001	2	Washer,Lock,9/16x.250x.060,Shldr
A2MP10	785-602	2	Screw,Mach,1/4-20x1-1/4,Rd,PH,Stl,ZP
A2MP11	12719	1	Terminal,Tab,M,1 Pair,.250x.032
A2MP12	710-004	1	Nut,Hex,6-32,ZP

* This item cannot be replaced without requiring the RT-200 System to be returned for recalibration at Timeter.

FIG.11.4 FLOW MODULE ASSEMBLY PICTORIAL

NOTE:

1. FILTER ASSY. A3MP1 IS REMOVED AND STORED IN THE 002-021 ACCESSORY POUCH DURING TRANSIT OF THE RT200 SYSTEM.



C. FLOW MODULE PARTS LIST

REFERENCE DESIGNATIONS REFER TO FIG.11.4 FLOW MODULE ASSEMBLY PICTORIAL.

Ref. Des.	Timeter Part No.	Qty	Description
A3	*12633	1	Module,Flow,RT203
A3A1	*025-016	1	Panel,Rear,Flow,Mod,Assy,RT203 (Note: the next 2 assemblies are included in p/n 025-016).
A3A1A1	*002-008	1	Valve Assy,RT203
A3A1A2	*003-004	1	LFE,Low Flow,Assy,RT203
A3A2	025-015	1	Panel,Front,FlowMod,Assy,RT203 (Note: The next assembly is included in p/n 025-015.)
A3A2A1	010-027	1	Board,Function Ind, Assy,RT203
A3A3	025-017	1	Panel,Bottom,Flow Mod,Assy,RT203 (Note: The next 2 items are included in p/n 025-017.)
A3MP16	603-002	4	Bumper,Rubber,Foot
A3MP17	740-640	4	Screw, 6-32 (Note: the next 2 assemblies are not included in p/n 025-017.)
A3A3A1	*010-023	1	Board,PC,Flow V/F,Assy,RT203
A3A3A2	*010-026	1	Board,PC,Flow Delta Press,Assy,RT203
A3A4	*003-005	1	LFE,High Flow,Assy,180 lpm,RT203
A3W1	008-035	1	Cable Assy, Flow Delta P to V/F,RT203
A3W2	008-036	1	Cable Assy,Valve to V/F,RT203
A3W3	008-034	1	Cable Assy,Function Ind,RT202/3
A3W6	008-037	1	Cable Assy,Thermistors to V/F,RT203
A3MP1	11534	1	External Filter Assy, 22mm (Note: 11534 must always be installed; except when the RT-200 is placed in transit case, then filter should be placed in accessory pouch 002-021.)
A3MP2	001-007	1	Adaptor,Front M/M,Assy,22mm,RT203 (Note: the next item is included in p/n 001-007.)
A3MP3	921-004	2	O-Rings
A3MP4	620-001	14	Tie,Cable,0.09x3.6"LG
A3MP5	710-002	2	Nut, Hex,6-32,Stl,ZP
A3MP6	730-002	10	Washer,Lock,#6,Int. Teeth,ZP
A3MP7	740-002	8	Screw,Mach,4-40x3/16,Rd,Slot,Stl,ZP
A3MP8	740-604	8	Screw,Mach,6-32x5/16,PN,PH,Stl,ZP
A3MP9	747-001	2	Rod,Thd,6-32 x 8-7/8",ZP
A3MP10	911-001	.750	Ft Tubing,Vinyl,Clr,1/16x1/8
A3MP11	043-001	2	Cap, Dust Cover,Assy,22mm
A3MP12	12710.0001	1	Tubing,1/8x1/4x8-1/4,PCV,Clear
A3MP13	12710.0002	1	Tubing,1/8x1/4x7-1/4,PVC,Clear
A3MP14	12719	1	Terminal,Tab,M,1 Pair,.250x.032
A3MP15	710-004	1	Nut,Hex,6-32,ZP
A3MP18	710-003	2	Nut,Hex,8-32,Stl,ZP
A3MP19	730-003	2	Washer,Lock,Intl T,Stl,ZP

* This item cannot be replaced without requiring the RT-200 System to be returned for recalibration at Timeter.

12. EQUIPMENT NEEDED

Common Hand Tools

Phillips screwdriver #2 point
Flat blade screwdriver 1/8" point
Flat blade screwdriver 3/16" point
Soldering/desoldering equipment
Needle nose/diagonal cutting pliers
Nutdriver 3/16"
Nutdriver 1/4"
Nutdriver 5/16"
Nutdriver 3/8"

Electrical Test Equipment

Digital Multimeter - Data Precision Model 2480
(Ranges required (accuracy of ± 1%): 0 - 200 VAC
0 - 20 VDC
0 - 10M Ohm)

Leakage Current Tester - Bio-Tek Model 170
(Range required (accuracy ± 1%): 0 - 100 ua AC)

13. STORAGE INSTRUCTIONS

Whether the RT-200 is being stored for short or long term:

- It should be kept in as dry an area as possible. Under no circumstances should the RT-200 be stored outside the humidity range of 10-90% relative humidity.
- Storage temperatures must be within -22 to 140°F (-33 to 60°C). The more constant the temperatures, the better.
- The area in which it is stored should be inspected periodically to insure that these conditions are met.

1. For short term storage: (a couple hours to a couple weeks)
   a. Disconnect all equipment and tubing from the RT-200.
   b. Put the caps (attached by beaded chains to the chassis) over the ends of the high flow inlet and outlet ports.
   c. Place the dust cover (provided) on the RT-200.

2. For long term storage:
   a. Disconnect all equipment and tubing from the RT-200.
   b. Repack the RT-200 into the transit case as specified in Chapter 3, section D.

14. GENERAL INFORMATION

IMPORTANT CAUTION

If the calibration EPROMS (A1A3A1 U1-U6), or any other integrated circuits (IC's), are removed for any reason, the following instructions must be followed to avoid any damage due to static electricty.

To help reduce the possibility of damage from electrostatic discharge (ESD), DO NOT perform the procedure below in a carpeted area or on other surfaces that generate static.

CHANGING EPROMS

1. Unplug the RT-200 power cord.
2. Remove the control module cover.
3. Locate the EPROMs in the control module (Figure 11.1). Get a piece of aluminum foil or conductive foam on which to place the EPROM after removal. Release the EPROM by turning the socket locking screw 1/4 turn counterclockwise. Touch the chassis of the control module to discharge any static potential. Carefully lift the EPROM from the socket and place it on the foil.
4. BE SURE TO INSTALL THE EPROM IN THE PROPER SOCKET with the notched end of the EPROM next to the socket locking screw. Lock the EPROM into place by turning the locking screw 1/4 turn clockwise.
5. Replace the cover and secure it with fasteners removed in step 2.

NOTE: Use these procedures to install new/additional RT-200 software from Timeter.

APPENDIX A

RECALIBRATION STATEMENT

To maintain accuracy, Timeter continues to recommend annual, factory recalibration of the RT-200. However, reviewing the data from returned units, we (Timeter) can make the following statement regarding recalibration. Our experience shows that the greatest factor affecting the RT-200's flow and volume accuracy is not time, but accumulation of particulate matter in the flow elements. Calibration history has shown that after one year the low flow range (0-5 lpm) may only be reliable to ± 4% of reading at 70°F* instead of our advertised ± 2% of reading accuracy claim. The high flow range (0-180 lpm) has been known to change ± 1% of reading accuracy to ± 2% reading accuracy after one year.

If there is a desire to recalibrate the RT-200 less frequently than once a year, you may do so provided you use a separate RT-200 as a transfer standard. The unit designated as a transfer standard must be used only as a transfer standard and must be recalibrated by Timeter every six months. Regular use of a transfer standard will allow you to verify the accuracy of a conventional RT-200 to within 1.4 to 2 times the advertised tolerance claims. For units that are free of foreign debris, the use of the transfer standard may reduce the required frequency of factory recalibrations.

* NOTE: ANSI recommends an accuracy of 2.5% of flow measurement reading for equipment used for checking breathing machines for medical use. Reference ANSI Z79.7-1976 FOR BREATHING MACHINES FOR MEDICAL USE Section 2.3.2.